Hydraulic Study

For the C-470 Corridor
Revised Environmental Assessment

April 2015

Submitted to:
CDOT Region 1
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1.0 Introduction

1.1 Location

The Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA) have identified a need for improvements to the C-470 corridor from Kipling Parkway to Interstate 25 (I-25). This portion of the C-470 corridor, approximately 13.75 miles in length, is herein referred to as the "Study Area". The Study Area is located in the South Denver Metropolitan area and crosses through portions of Douglas, Arapahoe, and Jefferson Counties as shown in **Figure 1**.

Figure 1. C-470 Corridor and its Surrounding Vicinity

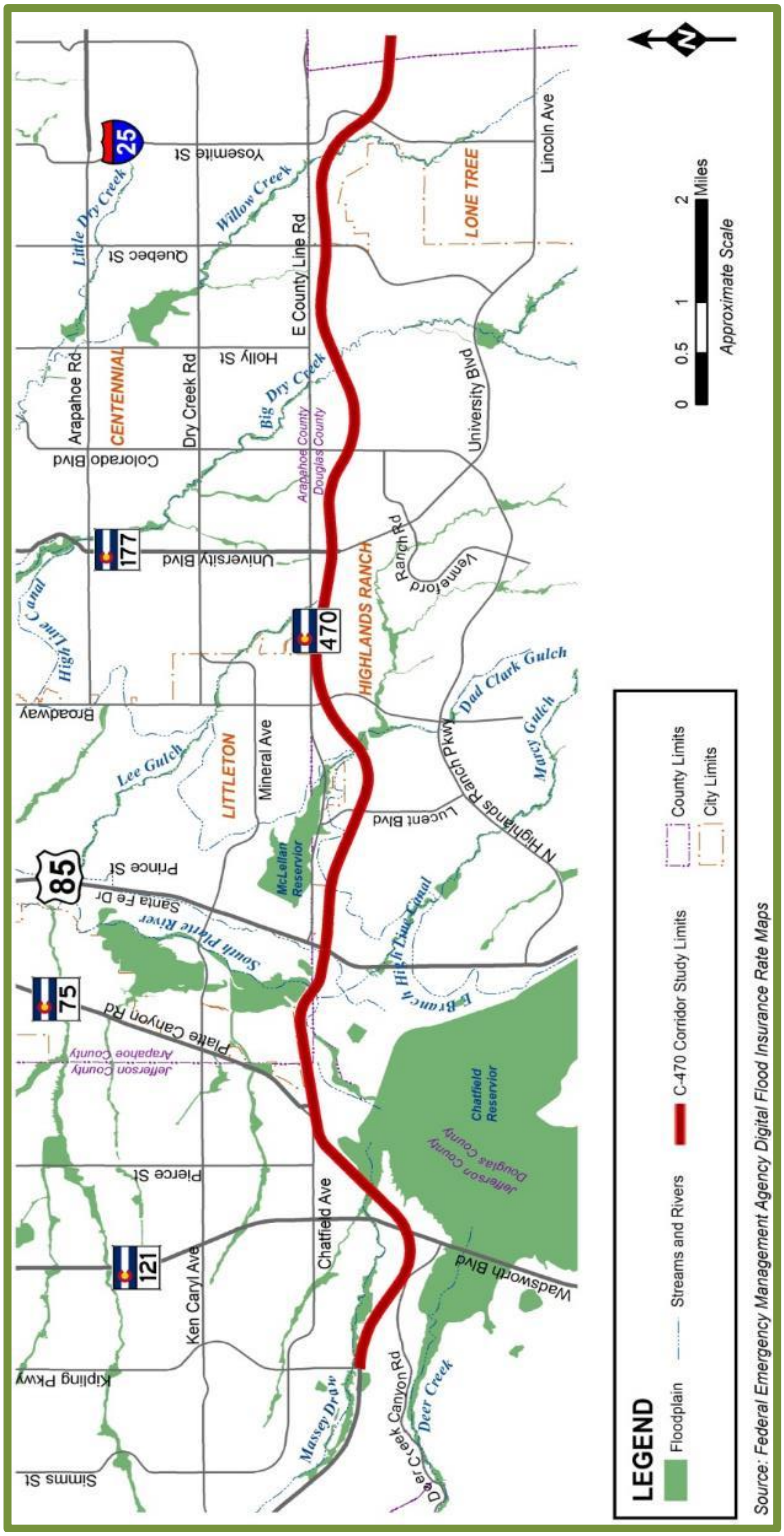
1.2 Purpose and Need

The purpose of proposed C-470 improvements is to address congestion and delay and improve travel time reliability for C-470 users.

During an interim phase of the Proposed Action, improvements will be completed through a portion of the Study Area. This hydraulic study was prepared in accordance with the requirements of the CDOT NEPA Manual, Section 9.5, Floodplains, which is based on requirements from FHWA, 23 CFR 650A. This Hydraulic Study for the ultimate project improvements is part of the Revised EA for the project and addresses potential environmental impacts on floodplains adjacent to or within the Study Area. Requirements to address potential changes to regulatory floodplains created under the National Flood Insurance Program are addressed in the *30% Design Drainage Report for the C-470 Corridor Coalition, Segment 1*.

The Study Area crosses several major drainageways. These drainageways include Massey Draw, the South Platte River, Dad Clark Gulch, Big Dry Creek, and Willow Creek. The locations of these major drainageways and their associated floodplains are shown on **Figure 2**.

Figure 2. Major Drainageways and Floodplains



1.3 Alternatives

Two alternatives are presented and evaluated in the 2015 Revised EA for the project. These are a No-Action Alternative and the Proposed-Action Alternative. The aspects of these alternatives that have potential environmental impacts on floodplains adjacent to or within the Study Area are described in the following paragraphs.

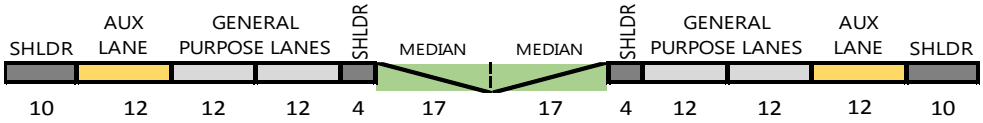
C-470 No-Action Alternative

The No-Action Alternative involves taking no action to improve the existing C-470 roadway or its drainageway crossing structures between Kipling Parkway and Interstate 25 other than performing basic maintenance and/or safety improvements to maintain roadway operation.

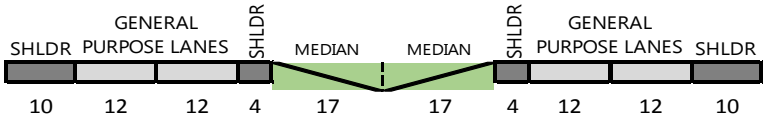
Within the Study Area, the existing C-470 roadway consists of two general-purpose lanes in each direction. An auxiliary lane in each direction exists between the Quebec Street interchange and the I-25 interchange, serving as continuous acceleration and deceleration lanes. The existing roadway (No-Action Alternative) consists of 12-foot travel lanes, including auxiliary lanes, with inside and outside shoulders, plus a 34-foot un-paved median, as shown in **Figure 3**. Paved shoulder widths vary between four and ten feet.

The major drainageways cross C-470 by means of culverts and by bridges over the South Platte River and over Big Dry Creek.

Figure 3. Typical Sections for No-Action Alternative



QUEBEC ST. TO I-25 – TWO LANES PLUS AUX LANE EACH DIRECTION
TOTAL WIDTH 134 FEET, 100 FEET IMPERVIOUS



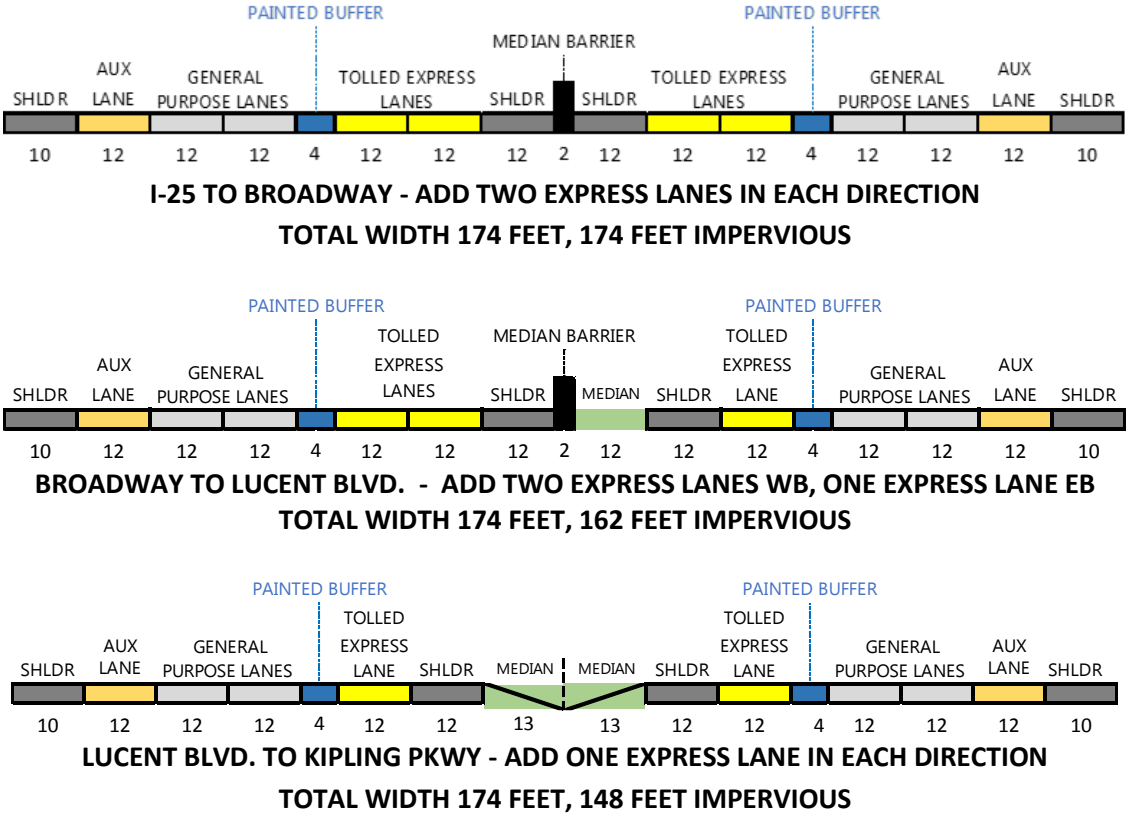
KIPLING PKWY TO QUEBEC ST - TWO LANES EACH DIRECTION
TOTAL WIDTH 110 FEET, 76 FEET IMPERVIOUS

C-470 Proposed Action

The Proposed Action would add one tolled express lane in each direction between I-25 and Kipling Parkway, and a second express lane between I-25 to Lucent Boulevard, westbound and Broadway to I-25, eastbound. These new through lanes, plus new auxiliary lanes, where warranted, would supplement the existing (free) general-purpose lanes, which would be reconstructed. The proposed typical sections are shown in

Figure 4. The project will also add new direct-connect ramps to serve some movements at the C-470/I-25 interchange.

Figure 4. Typical Sections for Proposed-Action Alternative



Potential impacts to adjacent regulatory floodplains could result from roadway widening, requiring the extension of cross culverts, or the replacement and widening of bridges over the S. Platte River and Big Dry Creek.

1.4 Flood History

Flooding in drainageways along the C-470 Corridor is typically due to short-duration, high-intensity precipitation events between the months of May and September. The various drainage master plans that are published document the history of significant flood events through the period from May 1844 to September 2002. The most noteworthy and destructive of these floods occurred in 1965. The 1965 flood caused a flow of approximately 110,000 cubic feet per second (cfs) in the South Platte River at Littleton and resulted in an estimated $300 million in damage to Denver. This flood occurred before C-470 and Chatfield Reservoir were constructed. Chatfield Reservoir was constructed on the South Platte River just upstream of the C-470 crossing after the 1965 flood to reduce the potential for flooding downstream.

With Chatfield Reservoir in place immediately upstream of C-470, flood flows on the South Platte River are controlled by how the reservoir is operated. The normal maximum release out of Chatfield Reservoir has been set at 5,000 cfs based on the U.S. Army Corps of Engineers (USACE) operating criteria and agreed upon regulations as described in the *Chatfield Reservoir Storage Reallocation Study*, USACE, July 2013. Therefore, this flow rate is used for the 100-year and 500-year flood events. If an extreme flood event were to occur in the Chatfield Reservoir watershed and the reservoir emergency spillway were overtopped, releases of a greater magnitude could occur.

1.5 Relevant Regulations

Federal

100-year floodplains within communities that participate in the National Flood Insurance Program (NFIP) must be managed in conformance with Code of Federal Regulations (CFR) Title 44, Part 60. One requirement of participating in the NFIP is that local communities adopt floodplain management ordinances that, at a minimum, are as stringent as CFR 44, part 60.

Local

The local jurisdictions that overlap the Study Area are Jefferson, Arapahoe, and Douglas Counties and the cities of Littleton and Lone Tree. All are participants in the NFIP and all have 100-year floodplain ordinances. The floodplains of the major drainageways within the Study Area are subject to the local floodplain regulations of the jurisdictions as follows:

- **Massey Gulch** - Jefferson County
- **South Platte River** - Jefferson, Arapahoe, and Douglas Counties and the City of Littleton
- **Dad Clark Gulch** - Douglas County
- **Big Dry Creek** - Douglas County
- **Willow Creek** – City of Lone Tree

1.6 Floodplain Mapping

All of these major drainageways have FEMA regulatory floodplain mapping that cross the Study Area. Images of FEMA Flood Insurance Rate Maps (FIRMs) at each of the crossing locations are provided in Appendix A-Floodplain Maps.

There are also Flood Hazard Area Delineation (FHAD) studies, Master Plans and Outfall System Planning Studies (OSPS) available for these drainageways and their tributaries, through the Urban Drainage and Flood Control District (UDFCD). A list of the above-mentioned documents is included in the reference section of this document.

The location of each floodplain is shown in relation to C-470 Study Area on **Figure 2**. Each major drainageway crossing is discussed in detail in Section 3.0.

2.0 No-Action Alternative Floodplain Impacts

No construction, excavation or fill is proposed with the No-Action Alternative and thus there would not be any impacts to the regulatory floodplains associated with any of the major drainageways.

3.0 Proposed Action Floodplain Impacts and Mitigation

3.1 General Discussion

Potential impacts to adjacent floodplains could result from roadway widening, requiring the extension of cross culverts, or the replacement and widening of bridges over the S. Platte River and Big Dry Creek. Relevant floodplains are discussed below in order from west to east as follows: Massey Draw, South Platte River, Dad Clark Gulch, Big Dry Creek and Willow Creek.

3.2 Massey Draw

Massey Draw crosses C-470 east of S. Wadsworth Blvd. and west of Chatfield Reservoir.

3.2.1 Floodplain and Impact Description

Where C-470 crosses Massey Draw, two existing reinforced concrete box culverts with approximate openings of 12'x10' and 12'x8.5' convey runoff from an approximately 8.5 square mile watershed. A photo of the downstream side of the box culvert at Massey Draw is shown in **Figure 5**.

Massey Draw has experienced recent flooding, most notably during the summer of 2004, in which floodwaters inundated numerous houses upstream of its crossing at South Oak Street. As a result, a revised FHAD and Conceptual Design Report were published for Massey Draw in 2005 and 2006 as part of a Major Drainageway Planning Update sponsored by UDFCD. Per the FHAD report, a 100-Year design flow of 3,816 cfs was determined to reach the crossing. Although the reports indicated that the culvert size should be increased somewhat (two 12'x10') to comply with allowable headwater standards, replacement of this structure is not proposed as part of this project. This structure is not proposed for replacement due to the cost of structure replacement and because no habitable structures are at risk of flooding on the adjacent public land.

Since the time of the master planning outfall study several LOMR's have been approved along the drainageway, however the detailed study and subsequent revisions to the FEMA floodplain have not extended east of Wadsworth Blvd. The FEMA Floodplain Map contained in Appendix A shows the effective floodplain as Zone A.

Figure 5. Downstream Side of Box Culvert at Massey Draw

3.2.2 Potential Risks Associated With the Proposed Action

The Federal government granted the C-470 easement, in which the project is contained at this location, and its conditions are administered by the USACE. This portion of the project is also located upstream of the Chatfield Reservoir. Due to the difficulty in modifying the easement (action by the U.S Congress) any disturbance or improvement beyond its limits have been excluded from consideration. In addition, the operational storage for Chatfield Reservoir extends up to elevation 5,500.0 feet. Any fill below this elevation requires that a compensatory storage volume be provided elsewhere below this level.

Although the roadway will be widened in this portion of the project, its profile is anticipated to closely match the existing roadway profile and the extension of the roadway embankment will be contained by proposed retaining walls. The culvert will not be extended and **No Encroachment** into the regulatory floodplain will occur at this location.

3.2.3 Potential Impacts on Natural and Beneficial Floodplain Values

Natural and beneficial floodplain values include fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aqua culture, forestry, natural moderation of floods, water quality maintenance, groundwater discharge, etc. Due to the proposed installation of retaining walls, the Proposed Action would not encroach into or modify the floodplain. Therefore, potential impacts on the Natural and Beneficial Floodplain values at this location will be avoided.

3.2.4 The Support of Probable Incompatible Floodplain Development

The Proposed Action would not encroach into or modify the Massey Draw floodplain. Therefore it would not create developable space or promote development within the FEMA floodplain. In addition, the floodplain is located on publicly owned land, which is not available for development.

3.2.5 Measures to Restore and Preserve Natural and Beneficial Flood Plain Values

Measures that can be implemented to restore, preserve, and enhance the floodplain values with construction include the implementation of temporary and permanent stormwater Best Management Practices (BMP's). The C-470 Proposed Action will address potential impacts during construction through the implementation of erosion and sediment control measures. It will provide for mitigation of increased runoff, and improved runoff quality through permanent flood control and water quality facilities.

3.2.6 Potential Concerns

There are no concerns related to the Proposed Action and the floodplain at this location. There may be some concerns regarding maintenance and the function of the trail crossing. The existing concrete box culverts are cracking, repair is needed, and the trail may be too frequently flooded due to the limited capacity of the crossing before the trail is overtopped.

3.3 South Platte River

The South Platte River crosses C-470 east of the Chatfield Reservoir and about one-half mile west of S. Santa Fe Dr.

3.3.1 Floodplain and Impact Description

The existing C-470 crossing over the South Platte River consists of both an east and westbound triple span bridge, supported by concrete abutments with riprap slopes and two concrete piers. The bridges are each roughly 40.5 feet wide by 171.5 feet in length possessing spans of approximately 50, 70 and 50 feet with an elevated 10' wide pedestrian walkway located under the westerly span. A photo of the upstream face of the crossing is shown in **Figure 6**.

A large grouted boulder grade control structure is located just downstream of the crossing about 250 feet from the roadway centerline. This structure establishes the elevation of the streambed and eliminates any concerns regarding long-term degradation.

As previously discussed, flood flows at the crossing are determined by releases from the Chatfield Reservoir operated by the USACE. The maximum design discharge from the reservoir is 5,000 cfs as stated in the *Chatfield Reservoir Storage Reallocation Study*, USACE, July 2013.

Figure 6. Upstream Side of Existing Bridges on the South Platte River

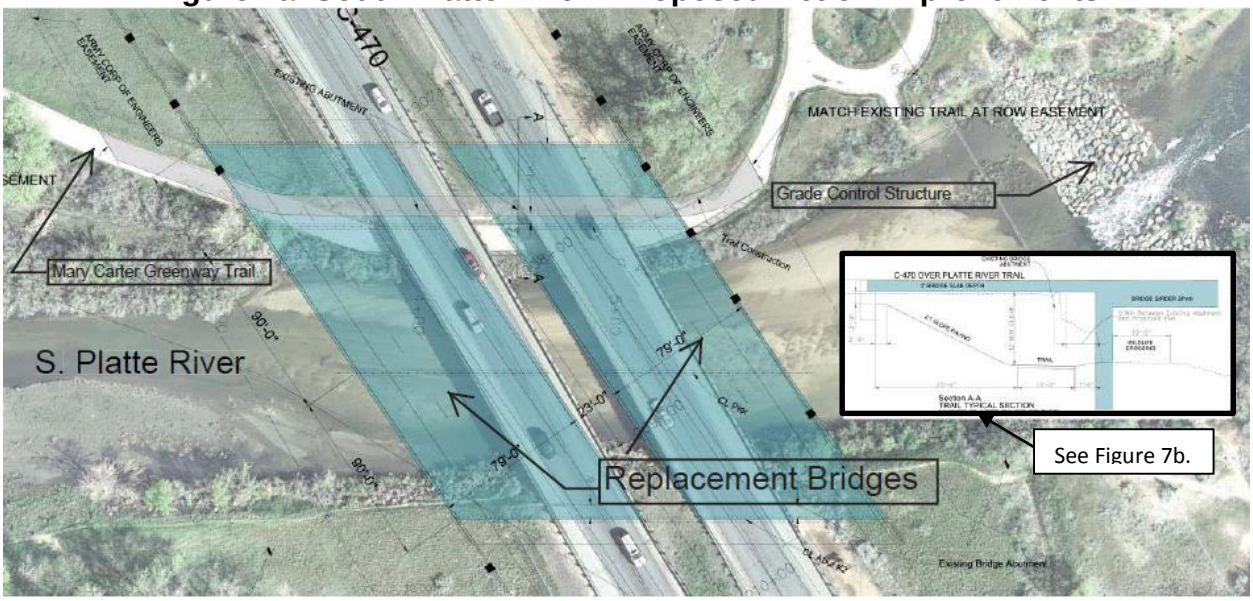
The Proposed Action includes the replacement of the two bridge structures with longer and wider structures. The existing two-pier structures will be replaced with two-pier structures with spans of 50, 90 and 90 feet with concrete abutments and sloping concrete or riprap protection. The new bridges will be skewed to the river channel about 30 degrees, similar to the existing structures.

Impacts to the S. Platte River floodplain were evaluated using a HEC-RAS hydraulic model to determine No Action and Proposed Action water surface profiles at the crossing. This analysis showed that the 500-year/100-year floodplain rises about 0.6 feet at the downstream face of the west bound Proposed Action bridge due to the flow remaining in a sub-critical flow condition at the proposed wider bridge span and the widening of the bridge in the downstream direction. The water surface quickly transitions to a level lower than the No-Action water surface about 70 feet upstream of the downstream face of the proposed west bound bridge. This rise is contained with public right-of-way and will not have any negative environment impacts. At the upstream face of the proposed east bound bridge the Proposed-Action water surface was calculated to be about 0.8 feet lower than the No-Action alternative. The regulatory floodplain boundary is shown upstream of C-470; however, there are no FIRM cross sections or Base Flood Elevations upstream of C-470. Therefore, a direct comparison to regulatory floodplain elevations was not completed.

The expected water surface lowering, upstream of the highway, is due to lengthening of the replacement bridges to accommodate improvements to the Mary Carter Greenway regional trail that crosses the project along the west bank of the S. Platte River. Proposed Action improvements provide increased clearances for trail use by raising the highway profile, lowering the trail profile and reducing the thickness of the bridge section over the trail. All of the proposed improvements are contained within the C-470 easement. The longer bridges and wider trail section will increase conveyance in the upper portion of the floodplain channel section, but will not change the main channel section, which carries most of the releases from the Chatfield Reservoir without encroachment onto the trail.

Figure 7a shows a plan view of the proposed replacement bridges relative to the existing bridges and river and **Figure 7b** shows a typical cross section of the bridge at the trail crossing. The No-Action and Proposed Action floodplain limits and the results of the hydraulic analysis are provided in Appendix B1 and the hydraulic model is provided on the enclosed disk. There will be **Minimal Encroachment** at this crossing.

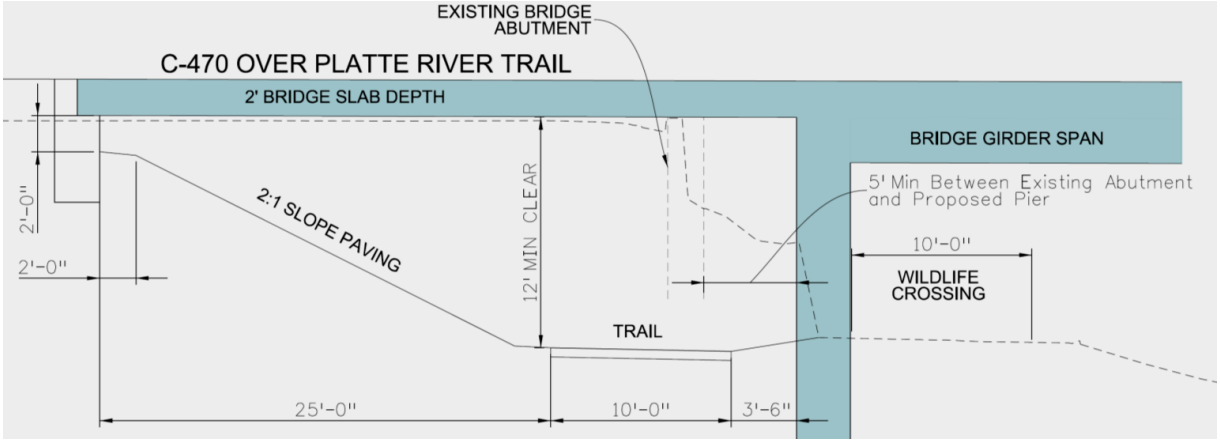
Figure 7a. South Platte River - Proposed Action Improvements



3.3.2 Potential Risks Associated With the Proposed Action

Potential risks for adversely affecting the regulatory floodplain at this crossing are limited and some reduction to flooding levels is expected. The floodplain will be somewhat wider toward the west under the new bridges, but will be lower and narrower outside of the C-470 easement upstream. There are no insurable structures adjacent to this location that would be affected by changes to the floodplain, and no increase in threats to public health and safety are expected.

Figure 7b. South Platte River 1 - Proposed Action Improvements
Mary Carter Greenway Typical Trail Section



3.3.3 Potential Impacts on Natural and beneficial Floodplain Values

Natural and beneficial floodplain values include fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aqua culture, forestry, natural moderation of floods, water quality maintenance, groundwater discharge, etc. Due to the existing downstream grade control structure and hardened channel banks, changes to the natural environment at this crossing will only result from construction of the bridge piers, that will replace the existing piers, and minor grading adjacent to the trail realignment. By maintaining the main channel configuration, potential impacts on the Natural and Beneficial Floodplain values at this location have been greatly reduced or eliminated.

3.3.4 The Support of Probable Incompatible Floodplain Development

Potential impacts are located under and immediately around the bridge crossing. Land adjacent to the crossing is publically owned parkland and there is no anticipation that the Proposed Action will create developable space or promote development within the FEMA floodplain.

3.3.5 Measures to Restore and Preserve Natural and Beneficial Floodplain Values

Measures that can be implemented to restore, preserve, and enhance the floodplain values include the implementation of temporary and permanent stormwater BMP's. Temporary BMPs will be implemented during construction, and the project will include the construction of permanent BMPs and peak flow reduction facilities within the South Platte River basin to comply with stormwater management permit requirements. These improvements related to the Proposed Action will improve the water quality of runoff to the river. The Proposed Action will also provide a planned wildlife crossing that improves the ability of wildlife to move along the river corridor.

3.3.6 Potential Concerns

The UDFCD is currently restudying the South Platte River floodplain. When available, the results of this analysis should be incorporated into the final Proposed Action design to confirm the results of the hydraulic analysis based on the preliminary design.

3.4 Dad Clark Gulch

Dad Clark Gulch crosses C-470 between Lucent Boulevard and South Broadway and enters McLellan Reservoir about one-quarter mile downstream of C-470.

3.4.1 Floodplain and Impact Description

Where C-470 crosses Dad Clark Gulch an existing 12'x6' RCBC and 36" RCP outlet convey runoff from two upstream storage facilities that are interconnected. The facilities have been constructed to reduce peak developed runoff rates to below historic rates, while providing water quality to the runoff coming from Dad Clark Gulch before it reaches McClellan Reservoir, which is a potable drinking water supply reservoir. Drainage report documents for the regional facility indicate that the existing culvert crossing at C-470 appears to be adequate to convey an estimated 100-year discharge of 1,283 cfs.

The floodplain associated with Dad Clark Gulch has been designated by FEMA as Zone A. The installation of proposed retaining walls with the C-470 widening improvements will prevent impacts to the existing floodplain and the existing outlet works; therefore, **No Encroachment** into the floodplain will occur at this location.

3.4.2 Potential Risks Associated With the Proposed Action

Although the roadway will be widened in this portion of the project, the roadway embankment will be contained by proposed retaining walls and the existing culvert will not be extended. Therefore, there are no potential risks due to the Proposed Action.

3.4.3 Potential Impacts on Natural and Beneficial Floodplain Values

Natural and beneficial floodplain values include fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aqua culture, forestry, natural moderation of floods, water quality maintenance, groundwater discharge, etc. Due to the installation of the retaining walls, grading impacts will be eliminated. Potential impacts on the Natural and Beneficial Floodplain values at this location have been eliminated.

3.4.4 The Support of Probable Incompatible Floodplain Development

The Proposed Action does not create developable space or promote development within the floodplain, which is located on publicly owned land.

3.4.5 Measures to Restore and Preserve Natural and Beneficial Flood Plain Values

Measures that can be implemented to restore, preserve, and enhance the floodplain values with construction include the implementation of temporary and permanent stormwater BMPs. The project will address potential impacts during construction and the existing water quality facility adjacent to the project will provide water quality treatment for the Proposed Action.

3.4.6 Potential Concerns

There are no identified concerns regarding the Proposed Action and the floodplain at this location.

3.5 Big Dry Creek

C-470 crosses the main branch of Big Dry Creek approximately 0.9 miles west of Colorado Boulevard.

3.5.1 Floodplain and Impact Description

At this location two 41.5’ wide x 128’ long single span bridges with sloping riprap-lined earth abutments have been constructed to convey C-470 traffic over the channel. **Figure 8** shows the downstream side of this crossing.

Information provided by FEMA FIRM Map No. 08035C0041 and the FIS study for Douglas County indicate that this portion of Big Dry Creek is designated as a FEMA Zone AE floodplain, with a peak 100-year discharge of 2,950 cfs produced from a watershed approximately 11.2 square miles in size.

Due to upstream development and stream degradation, the channel bottom (thalweg) of Big Dry Creek has changed since the original bridge was designed and constructed. This is typical for alluvial streams in the Denver area. The current streambed has been stabilized with grade control structures downstream and upstream of the crossing, therefore, no further degradation of the channel is expected and the floodplain should remain stable. The expansion of the existing bridge will maintain the same span and channel section, but will be increased in width to accommodate the increased width of C-470. This will extend the roadway embankment upstream and downstream within the floodplain. The extended embankment will be smoothly transitioned into the existing embankment to avoid abrupt changes and hydraulic losses. **Minimal Encroachment** into the regulatory floodplain is expected to occur at this location.

Figure 8. Downstream Side of Existing Bridge at Big Dry Creek

3.5.2 Potential Risks Associated With the Proposed Action

As discussed previously, encroachments to the upstream and downstream embankment slopes as a result of widening of the structure could result in a minor increase of floodplain elevations. Any increase of the floodplain elevation would occur on the upstream adjacent property, which is used for open space, and a golf course where no insurable structures are located and no increase in threats to public health and safety are expected.

3.5.3 Potential Impacts on Natural and beneficial Floodplain Values

The only potential impacts to natural and beneficial floodplain values would result from minor encroachments to widen the bridge upstream and downstream within existing highway right-of-way. These improvements would involve a limited portion of the channel above the normal high water level and could be constructed with minimal or no impacts on the adjacent floodplain.

3.5.4 The Support of Probable Incompatible Floodplain Development

The Proposed action does not modify the floodplain in a manner that would support incompatible floodplain development. The adjacent property is already fully developed and includes open space and a golf course.

3.5.5 Measures to Restore and Preserve Natural and Beneficial Flood Plain Values

Measures that can be implemented to restore, preserve, and enhance the floodplain values include the implementation of temporary BMPs during construction and permanent stormwater BMPs in other portions of the project. Vegetation that is disturbed by the project will be restored.

3.6 Willow Creek

C-470 crosses Willow Creek approximately 0.5 miles west of Yosemite Blvd.

3.6.1 Floodplain and Impact Description

Runoff reaching this location is conveyed north under the roadway by triple 12'x12' reinforced concrete box culverts. As shown in the **Figure 9** photo, the westerly culvert also functions to convey pedestrian traffic. This culvert will be extended upstream with the proposed widening of C-470. The culvert will not be extended downstream. The length of the extended culvert will be limited by the construction of a retaining wall to stay within the available right-of-way.

The adjacent floodplain has been designated as a Zone A. At the limit of the detailed FIS, downstream of this location, a 100-year flow rate of 2,419 cfs was used. However, this value was based on land uses at the time of the study (September 30, 2005). Drainage basin studies completed since the FIS have included estimates of flow resulting from completed and proposed upstream development. The Outfall Systems Planning Study (OSPS), CH2M Hill, February 2010, estimated a future flow of 4,236 cfs at County Line Rd. and the flow profile (Figure B-8) from that study shows that the 100-year flow at C-470 is estimated to be about 3,500 cfs.

The OSPS proposed a regional detention pond on Willow Creek just upstream of C-470 that would reduce the 100-year flow. However, based on conversations with City of Lone Tree engineers, this improvement is not likely to be constructed. Therefore, the potential impact of the Proposed-Action was evaluated based on the undetained future land use condition 100-year flow of 3,500 cfs.

A preliminary hydraulic analysis was completed to evaluate the potential impact of the encroachment on the floodplain. A hydraulic model received from the UDFCD was modified to show the Proposed Action improvements. It was assumed that the existing culvert section and slope will be extended upstream to match the existing creek bottom. Based on the 100-year flow rate of 3,500 cfs and the preliminary design for the culvert extension, the analysis showed a potential increase of 0.3 feet in the 100-year water surface from the pre-project to the post-project conditions immediately upstream of the extended culvert. However, this estimated increase in water surface elevation is eliminated within a few hundred feet upstream of the culvert. The results of the hydraulic analysis for the No-Action and Proposed Action conditions are provided in Appendix B2 and the hydraulic model is provided on the enclosed disk. Floodplain regulations allow for an increase of up to 1.0 feet in Zone A floodplains. Therefore, **Minimal Encroachment** is expected from the Proposed Action at this crossing.

Figure 9. Upstream Side of Existing Culvert at Willow Creek Crossing

3.6.2 Potential Risks Associated With the Proposed Action

The upstream segment of Willow Creek that is potentially impacted from the Proposed Action is within publically owned land being used as open space, there are no insurable structures that could be affected and no increase in threats to public health and safety are expected.

3.6.3 Potential Impacts on Natural and Beneficial Floodplain Values

Improvements required by the Proposed Action will require that a short section of Willow Creek, that is currently open channel, will be within the extended box culvert and roadway embankment fill adjacent to the box culvert will also encroach into the creek. The area affected by this encroachment is small, but will need to be covered under a floodplain development permit and other environmental permits, as needed.

3.6.4 The Support of Probable Incompatible Floodplain Development

Potential impacts are located immediately adjacent to the existing roadway facilities primarily within the C-470 right-of-way. The Proposed Action would not create developable space or promote development within the regulatory floodplain. The land adjacent to the floodplain is publicly owned open space and is not expected to be developed.

3.6.5 Measures to Restore and Preserve Natural and Beneficial Flood Plain Values

Measures that can be implemented to restore, preserve, and enhance the floodplain values include the implementation of temporary and permanent stormwater BMPs. Water quality improvements constructed with the project will provide benefits to the downstream system. The stabilization of the embankment adjacent to the stream will reduce erosion and downstream sedimentation. The disturbance of vegetation due to

construction of the culvert extension will be mitigated by revegetation of the disturbed areas.

4.0 Conclusions

The drainageways with floodplains that cross the project have either Zone A, approximate floodplains, or Zone AE, detailed study floodplains. The type of floodplain for each of the drainageways is as follows:

- Massey Draw – Zone A
- S. Platte River – Zone AE
- Dad Clark Gulch – Zone A
- Big Dry Creek – Zone AE
- Willow Creek – Zone A

Potential impacts to Massey Draw and Dad Clark Gulch were avoided because retaining walls will be used to avoid extending existing cross culverts. Therefore, there will be **No Encroachment** into these floodplains.

Potential impacts to the S. Platte River floodplain were evaluated using a hydraulic model (See Appendix B1) to determine No Action and Proposed Action conditions. This analysis showed that the 100/500-year water surface just downstream of the proposed, wider bridge may rise about 0.6 feet and the 100/500-year water surface upstream of the crossing will be lowered about 0.8 feet. The minor rise in the downstream water surface is due to the widening of the bridge section and the change in flow regime due to the longer bridge span. The lowering is due to the lengthening of the replacement bridges to accommodate improvements to the Mary Carter Greenway regional trail that crosses the project along the west bank of the S. Platte River.

Proposed Action improvements provide increased clearances for trail uses by raising the highway profile, lowering the trail profile and reducing the bridge section over the trail. The longer bridges and wider trail section increase the conveyance of the upper portion of the floodplain section under the proposed bridges, but do not affect the main channel section, which carries most of the releases from Chatfield Reservoir without overtopping the trail. The planned wildlife crossing included in the longer bridge span section will improve wildlife movement along the river corridor.

All of the improvements are contained within the C-470 easement; therefore, there are no impacts beyond the easement limits. Therefore, there will be **Minimal Encroachment** at this crossing.

The replacement of the bridges over Big Dry Creek will maintain the current span and will not reduce the channel section through the bridge. The widening of the bridge section will require minor encroachment into the upstream and downstream floodplain

adjacent to the roadway embankment, but will have only **Minimal Encroachment** at this crossing.

The extension of the existing culvert at Willow Creek upstream was evaluated using a hydraulic model (See Appendix B2) resulted in an increase of 0.3 feet during the 100-year flood. However, this rise immediately upstream of the extended culvert will be eliminated within a few hundred feet of the culvert entrance. Also, the Willow Creek drainageway is located within publically owned land being used as open space that will not be developed. Therefore, there will be **Minimal Encroachment** into this floodplain.

The project will be designed to minimize impacts and where they are unavoidable, to limit them by the restoration of disturbed areas. There are no insurable structures adjacent to the drainageways that may be placed at greater risk due to potential impacts to floodplains and no changes to the floodplain will provide additional opportunity for incompatible development.

Therefore, the Proposed Action will have **No Encroachment** or **Minimal Encroachment** on the floodplains that cross or are located adjacent to the Study Area.

References

Arapahoe County Stormwater Management Manual, Revised July 5, 2011.

Arapahoe County Land Development Code, June 30, 2010.

Colorado Department of Transportation Drainage Design Manual, dated 2004
City of Littleton Zoning Ordinance, Revised 6-11-1992.

Douglas County Storm Drainage Design and Technical Criteria Manual, Amended July 8, 2008.

Douglas County Zoning Resolution, dated March 10, 1999.

Home Rule Charter and Code of the City of Lone Tree, Colorado, dated 2004.

Federal Emergency Management Agency, Flood Insurance Study, Arapahoe County, Colorado and Incorporated Areas, Volume 1 and 4 of 4, December 17, 2010.

Federal Emergency Management Agency, Flood Insurance Study, Douglas County, Colorado Unincorporated Areas, Volume 1 and 2 of 3, September 30, 2005.

Flood Insurance Rate Map Panel(s) 28, 33, 34, 36, and 41 of 495 Douglas County Colorado, Revised September 30, 2005.

Federal Emergency Management Agency, Flood Insurance Study, Jefferson County, Colorado and Incorporated Areas, Volume 1 of 7, June 17, 2003.

Flood Insurance Rate Map Panel(s) 0415E Jefferson County Colorado and Incorporated Areas, Revised by LOMRs, Effective February 19 2008, and Effective March 23, 2009.

Flood Insurance Rate Map Panel 433 of 725 Arapahoe County Colorado and Incorporated Areas, Revised December 17, 2010.

Jefferson County Storm Drainage Design & Technical Criteria, adopted March 24, 2009.

Jefferson County Zoning Resolution, Adopted August 27-2013.

Master Plan of Drainage Addendum Dad Clark Gulch, by Nolte and Associates, Revised September 1997.

National Environmental Policy Act Manual, Section 9.5, Floodplains, Colorado Department of Transportation, October, 2014.

Urban Drainage and Flood Control District, Electronic Data Management Maps.

APPENDIX A – FLOODPLAIN MAPS

This appendix contains copies of FEMA FIRMs for each of major drainageways crossing the project.

Map A1: **Massey Draw**: FEMA FIRM Map No. 08059c0415E Revised by LOMR Effective Feb 19 2008

Map A2: **South Platte River**: FEMA FIRM Map No. 08005C0433K, Revised December 17, 2010

Map A3: **Dad Clark Gulch**: FEMA FIRM Map No. 08005C0036F, Effective September 30, 2005

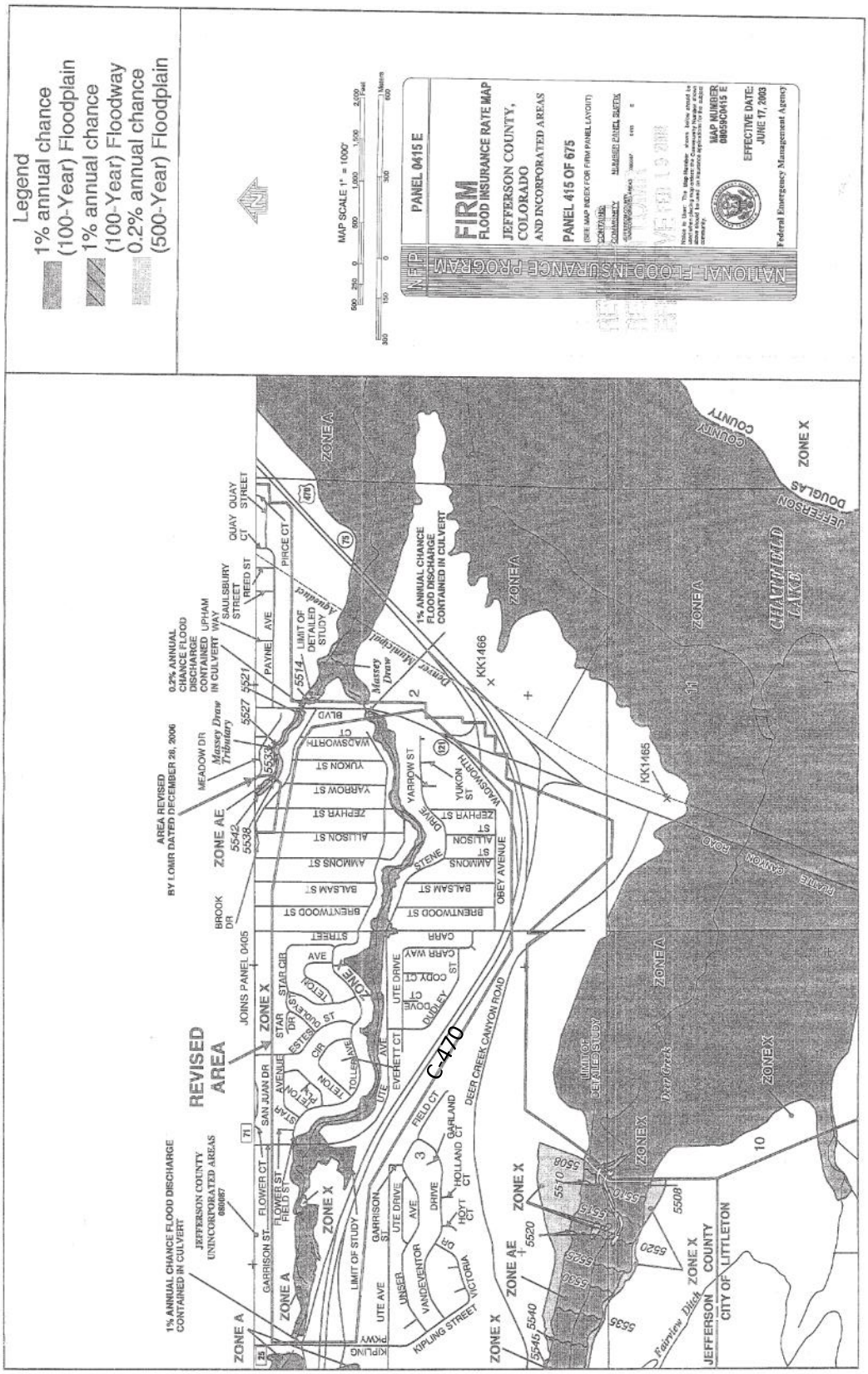
Map A4: **Big Dry Creek**: FEMA FIRM Map No. 08005C0033F, Effective September 30, 2005

Map A5: **Big Dry Creek**: FEMA FIRM Map No. 08005C0041F, Effective September 30, 2005

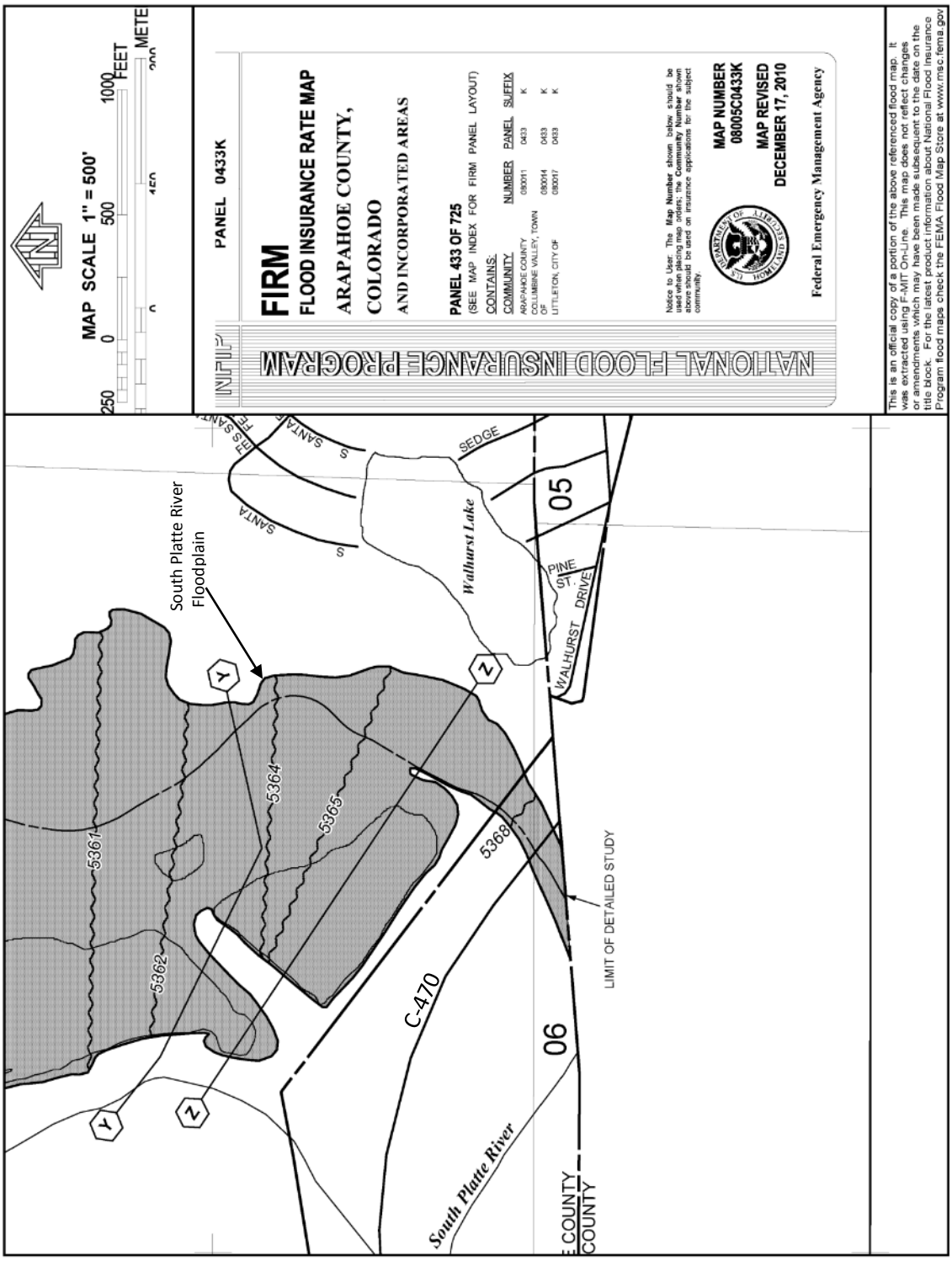
Map A6: **Willow Creek**: FEMA FIRM Map No. 08005C0034F, Effective September 30, 2005

Map A7: **Willow Creek**: FEMA FIRM Map No. 08005C0042F, Effective September 30, 2005

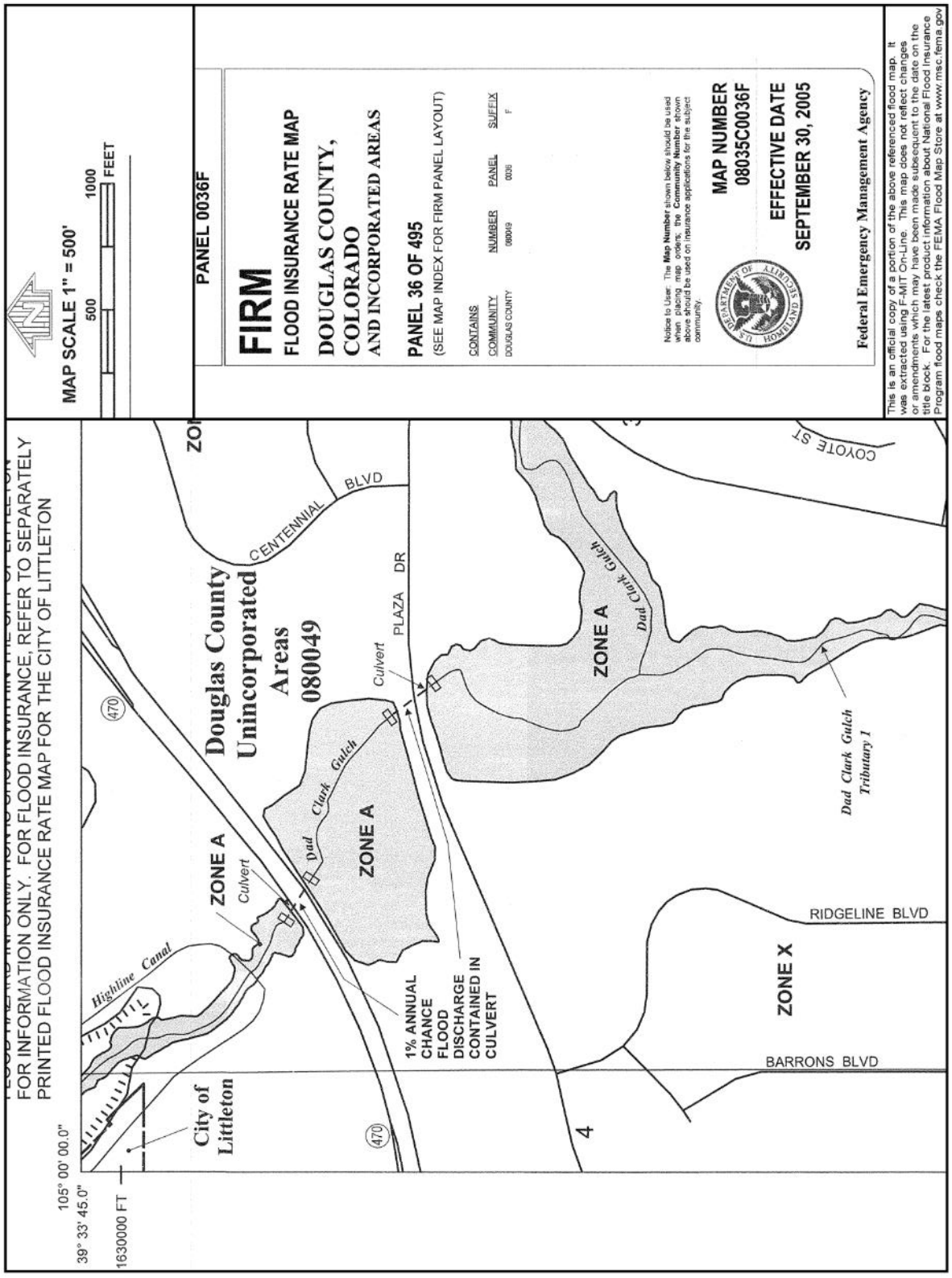
Map A1- Massey Draw



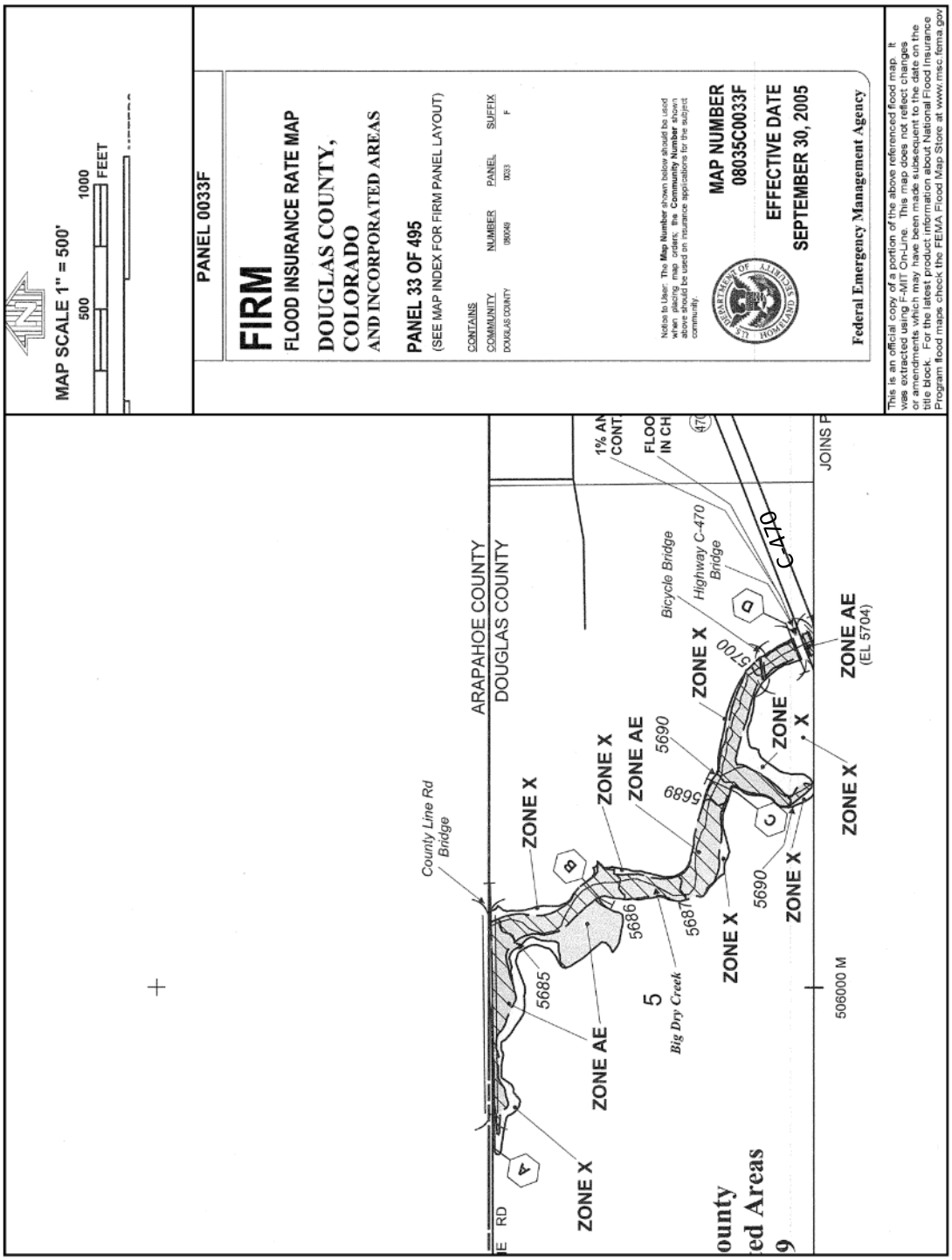
Map A2- South Platte River



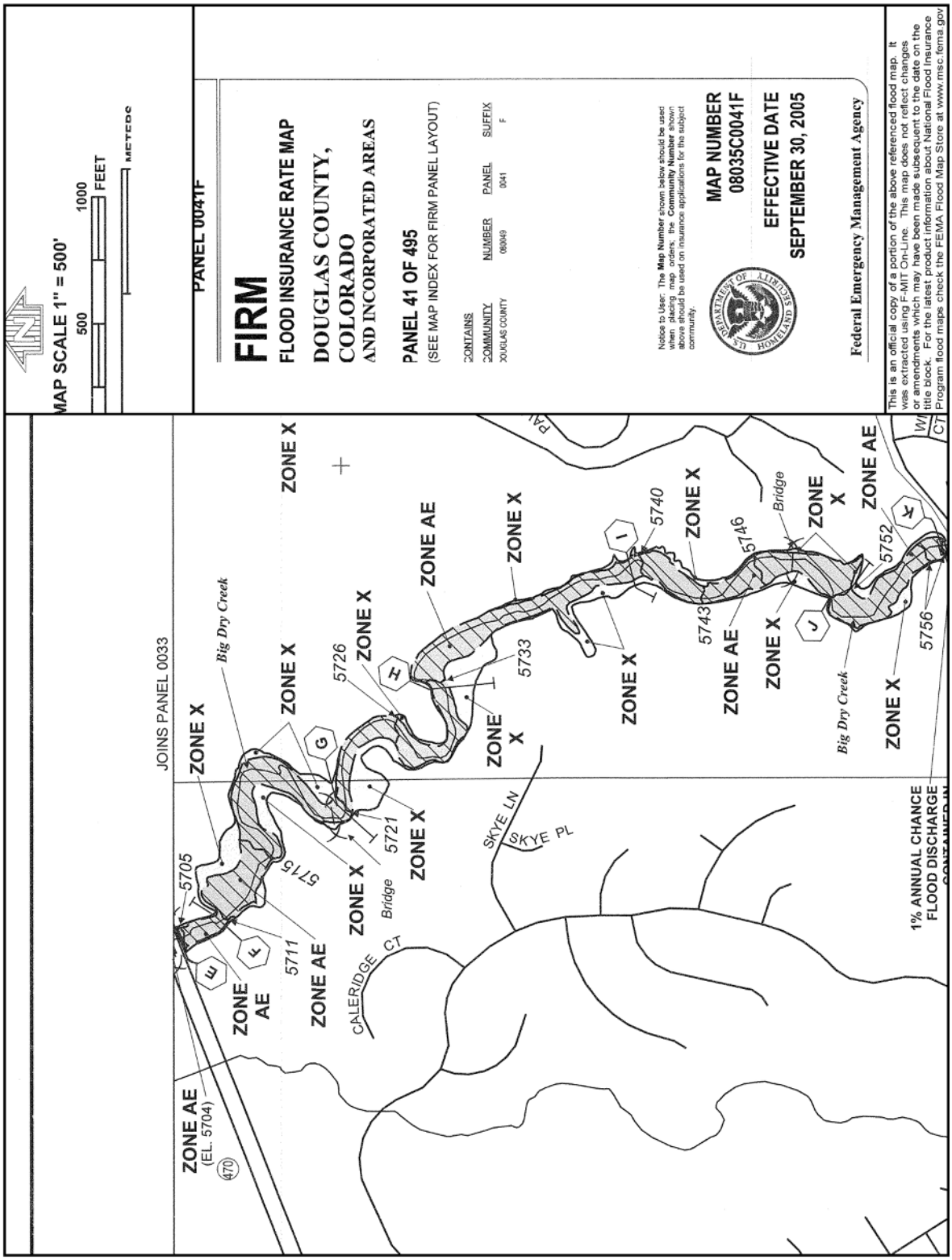
Map A3- Dad Clark Gulch



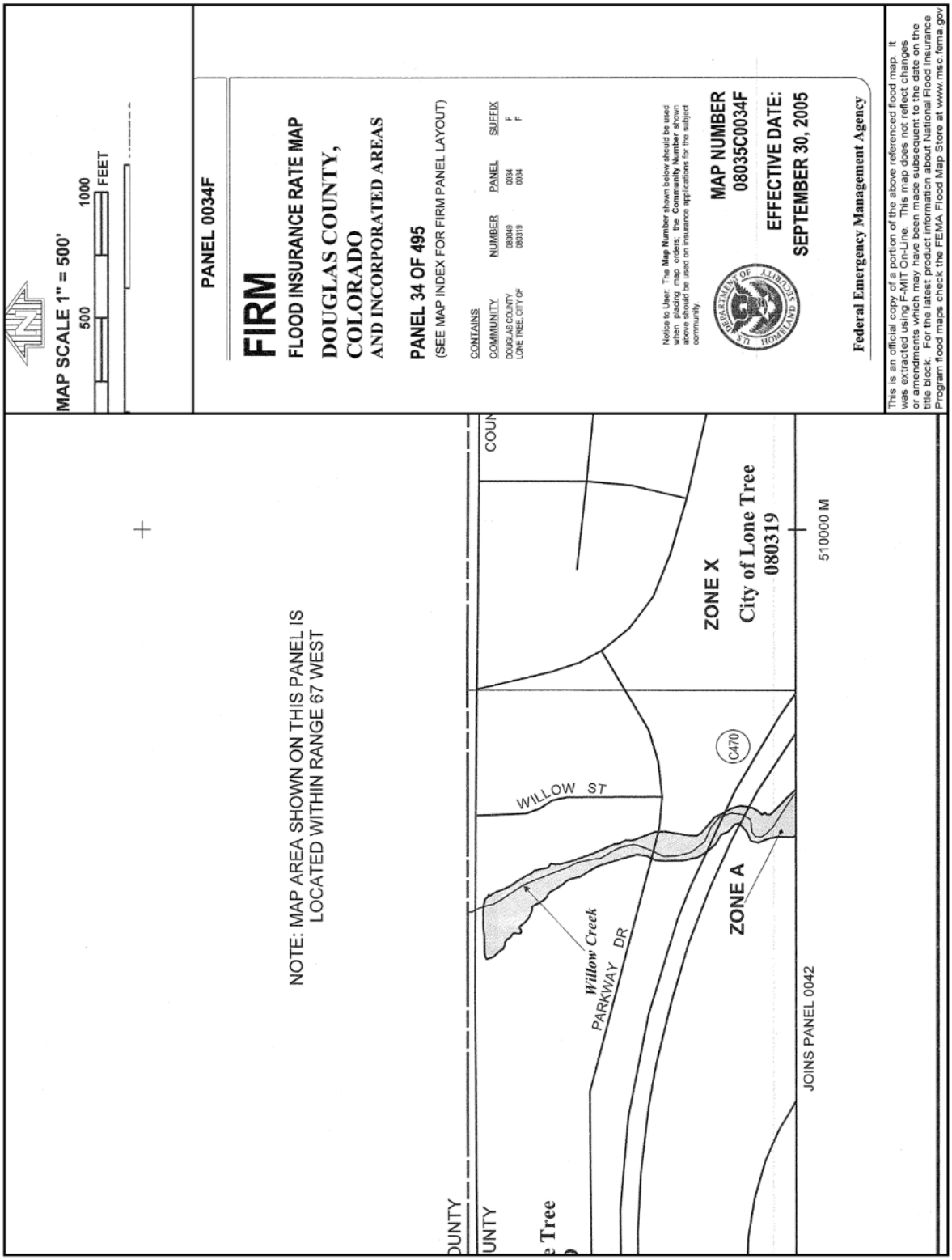
Map A4- Big Dry Creek



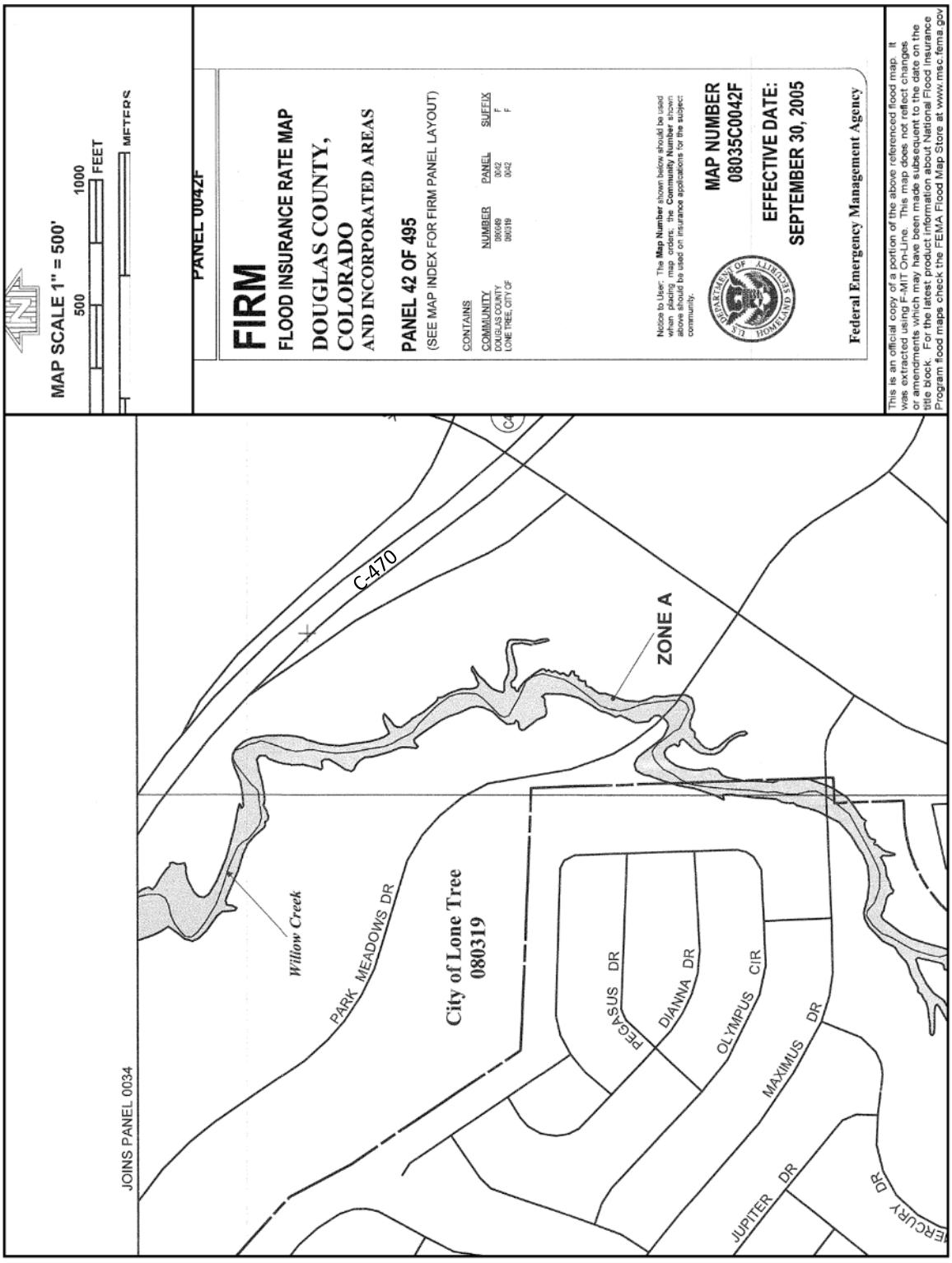
Map A5- Big Dry Creek



Map A6- Willow Creek



Map A7- Willow Creek



APPENDIX B – HYDRAULIC ANALYSES

Appendix B1 - South Platte River Bridge

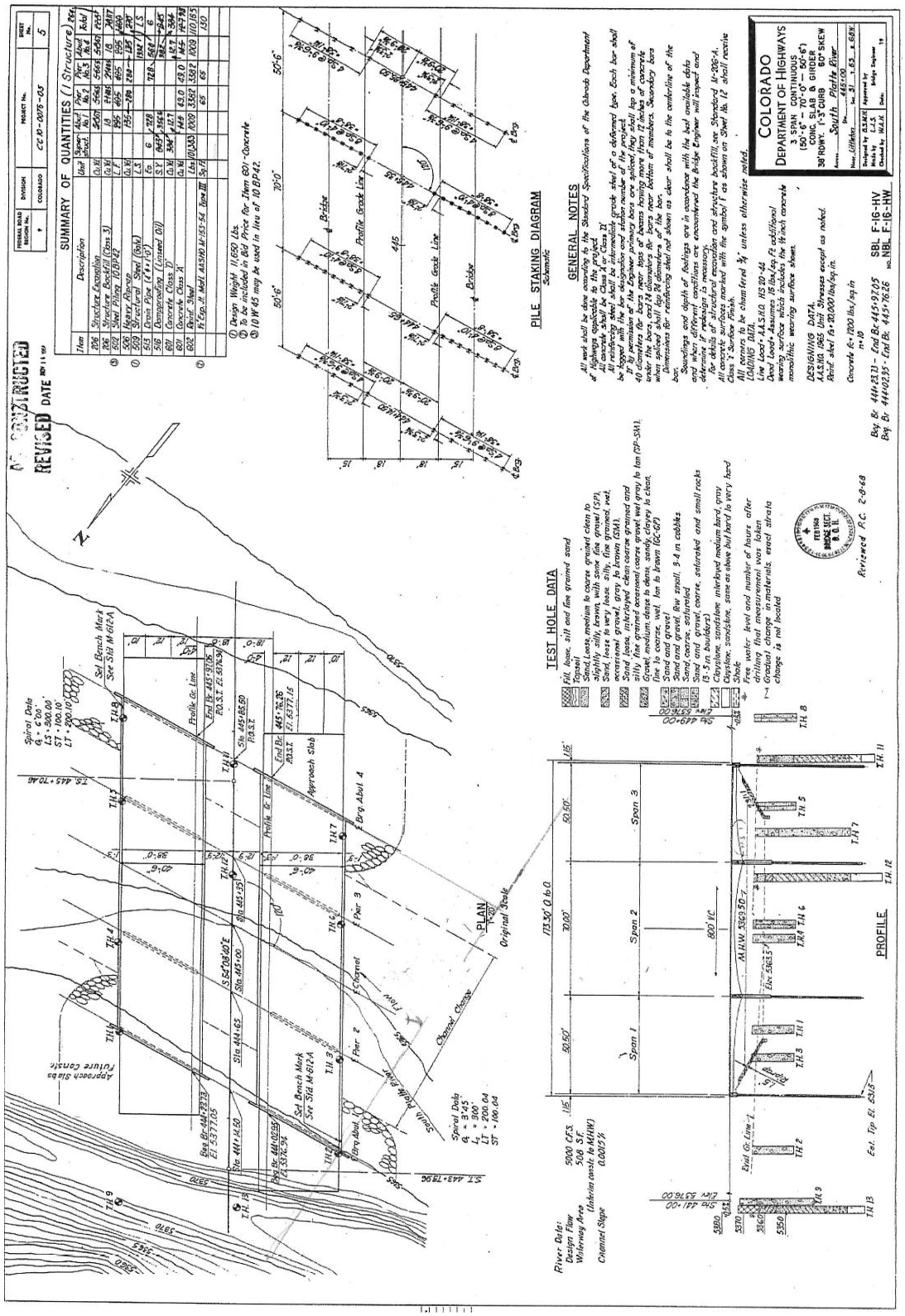
Appendix B2 - Willow Creek Culvert Extension

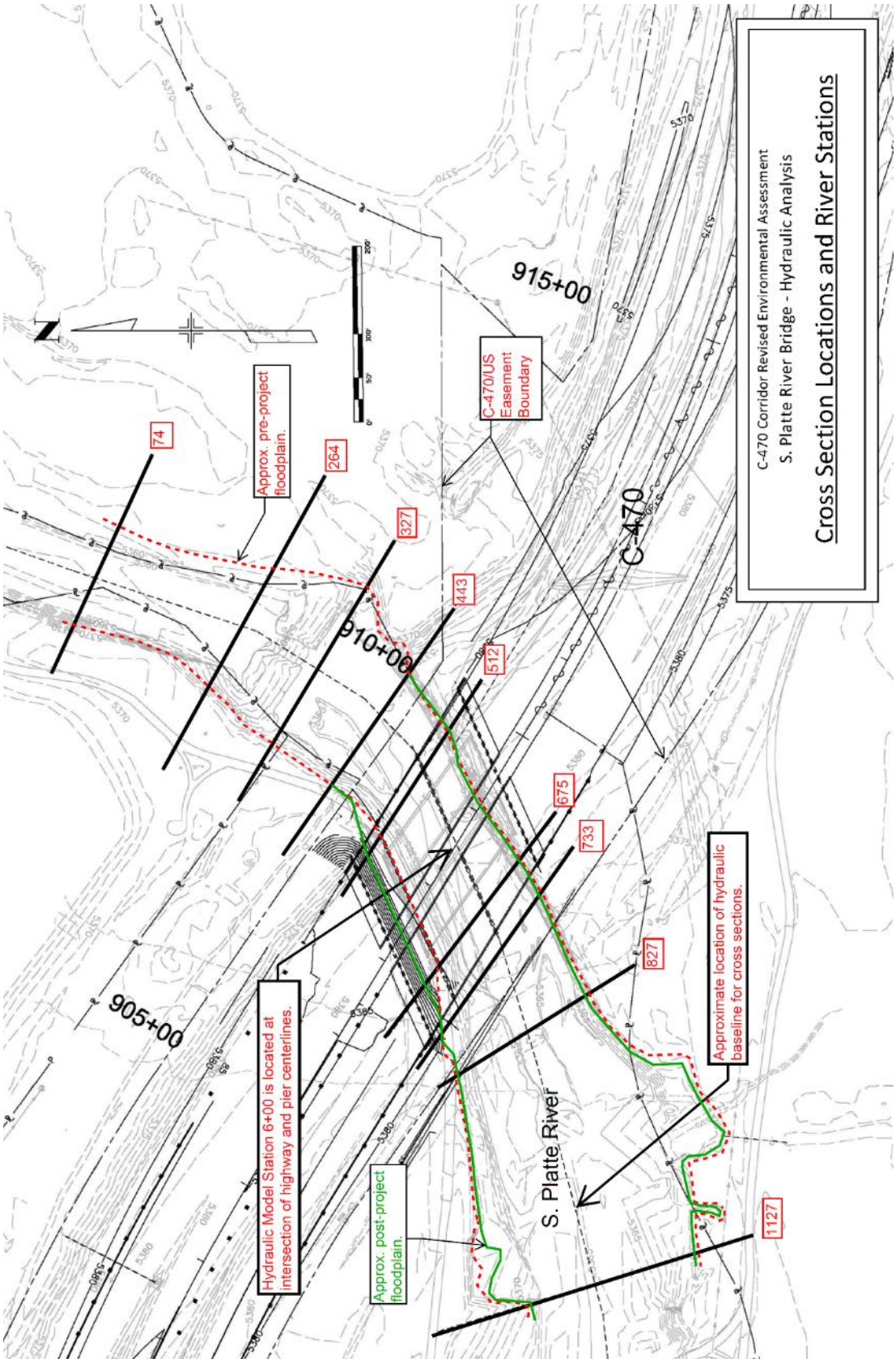
Appendix B1

South Platte River Bridge

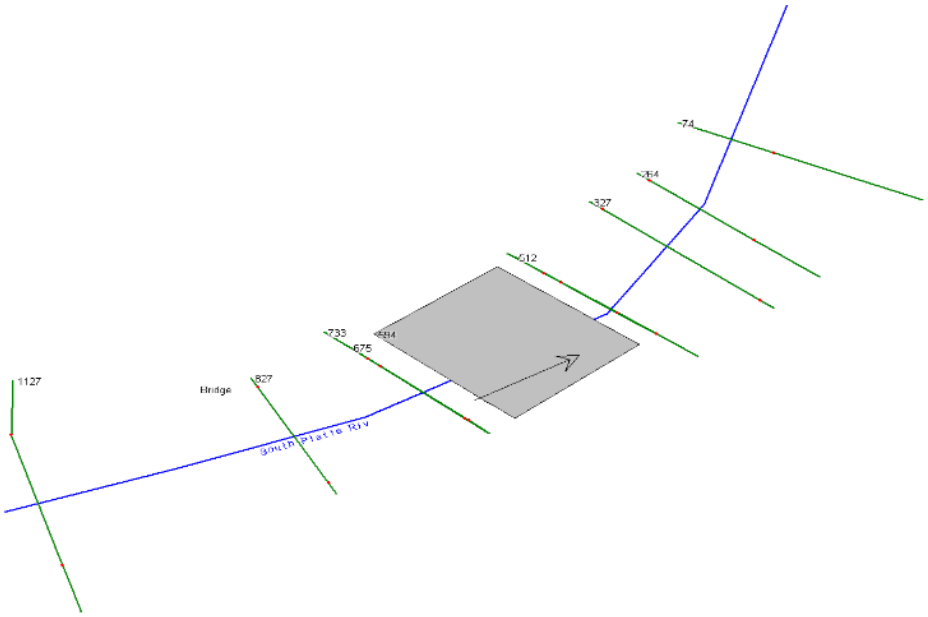
Hydraulic Analysis Data

S. Platte River Bridge
Existing Bridge As-Built

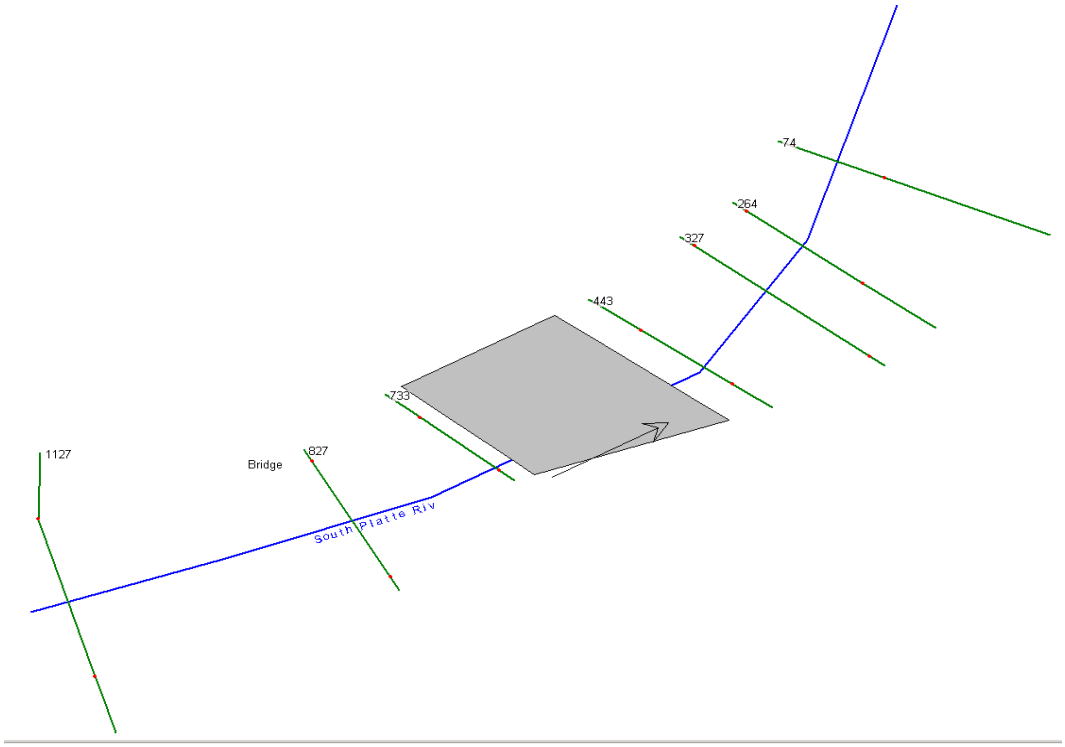

REVISED
COLORADO
SUMMARY OF QUANTITIES (1 Structure)
GENERAL NOTES
TEST HOLE DATA
PILE STAKING DIAGRAM
PLAN
PROFILE
COLORADO
DEPARTMENT OF HIGHWAYS
3 SPAN CONTINUOUS
(50'-6" – 70'-0" – 50'-6")
CONC. SLAB & GIRDER
38'ROW x 73°08'00" RT. SKEW
South Platte River
SBL F-16-HV
NBL F-16-HW


Cross Section Locations and River Stations
C-470 Corridor Revised Environmental Assessment
S. Platte River Bridge - Hydraulic Analysis
915+00
910+00
905+00
C-470
C-470/US Easement Boundary
Approx. pre-project floodplain.
Approx. post-project floodplain.
Hydraulic Model Station 6+00 is located at intersection of highway and pier centerlines.
Approximate location of hydraulic baseline for cross sections.
S. Platte River
74
264
327
443
512
675
733
827
1127

S. Platte River Bridge
Hydraulic Plan Cross-Section Locations
No Action & Proposed Action Alternatives

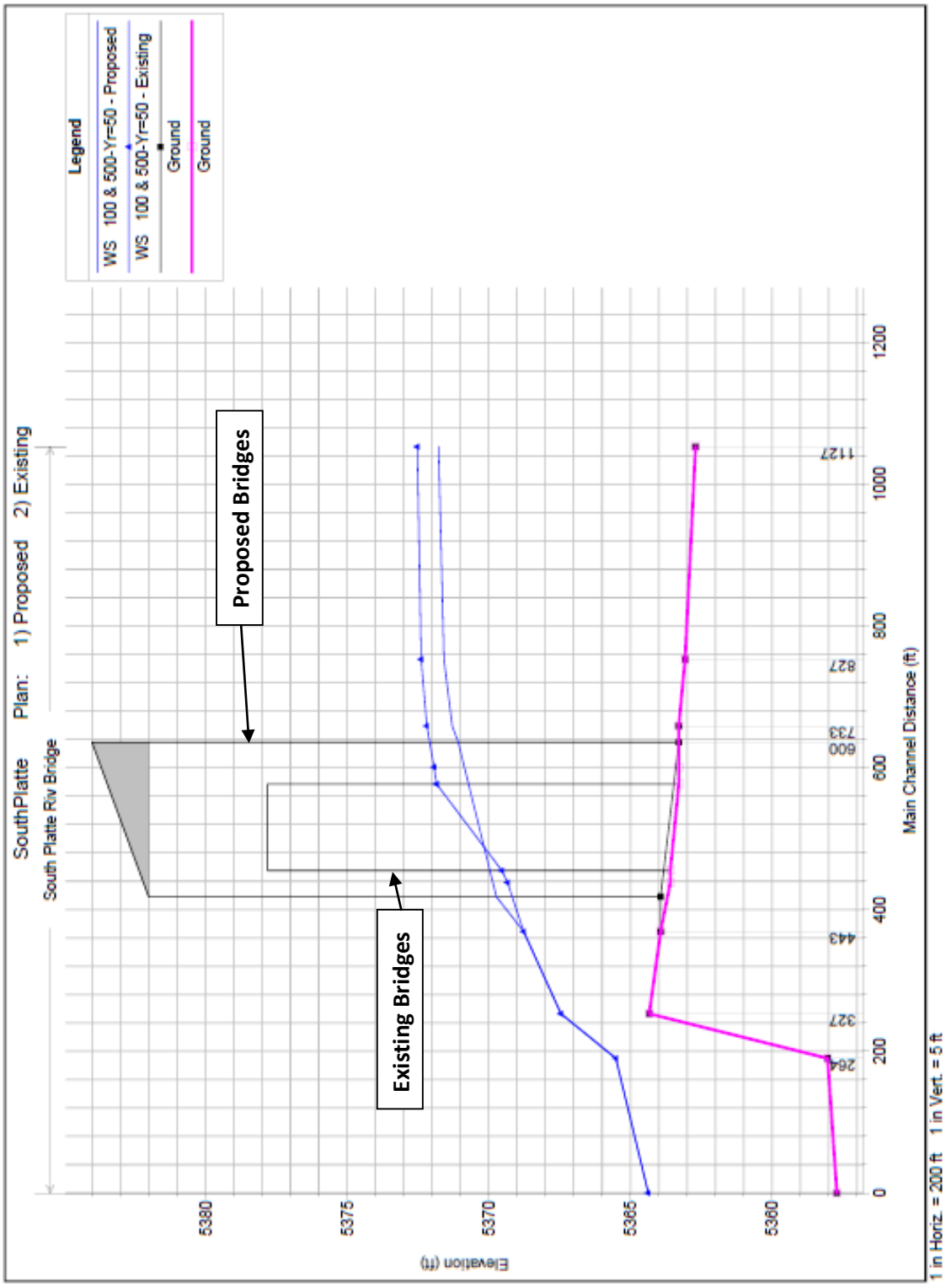


No Action

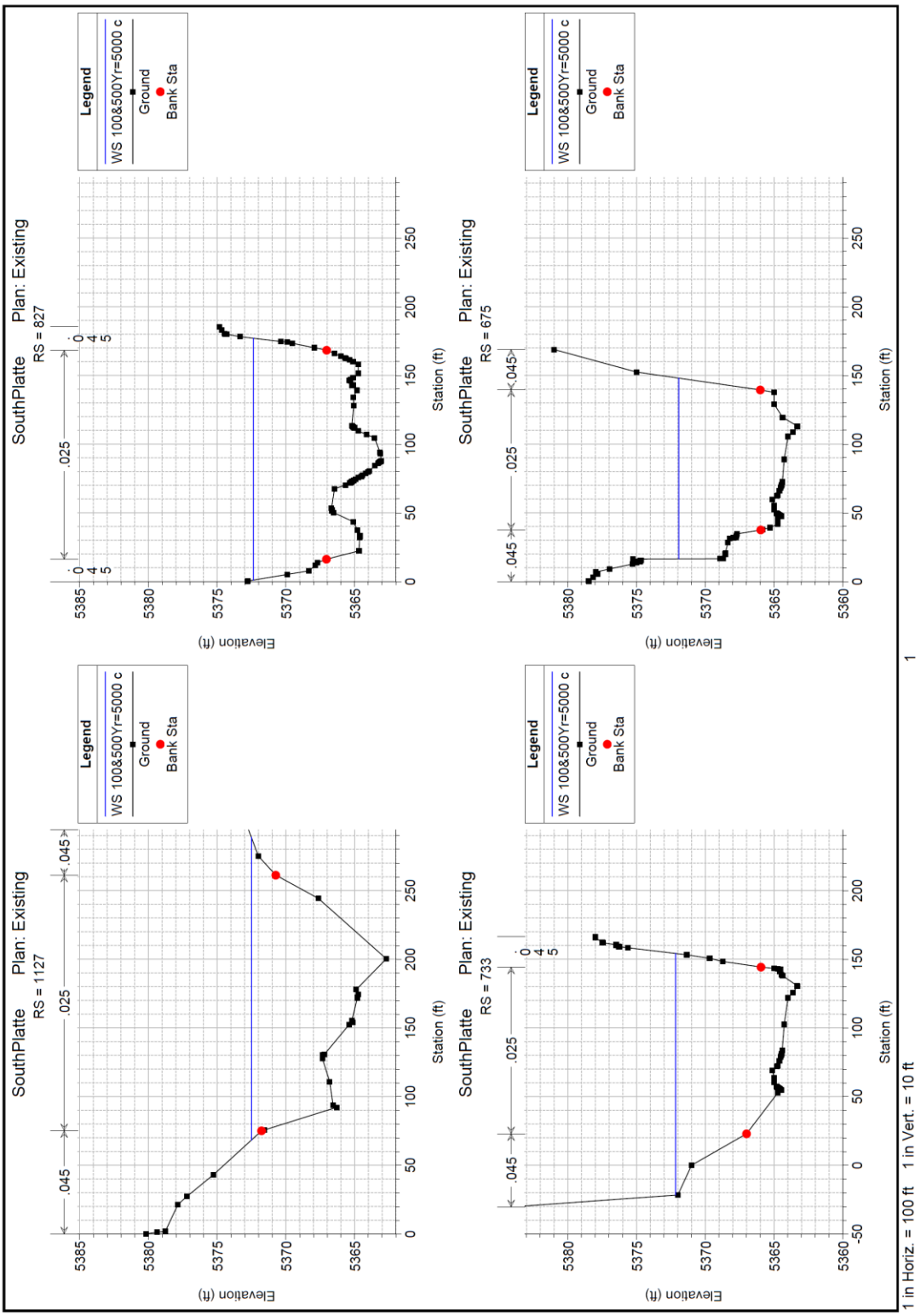


Proposed Action

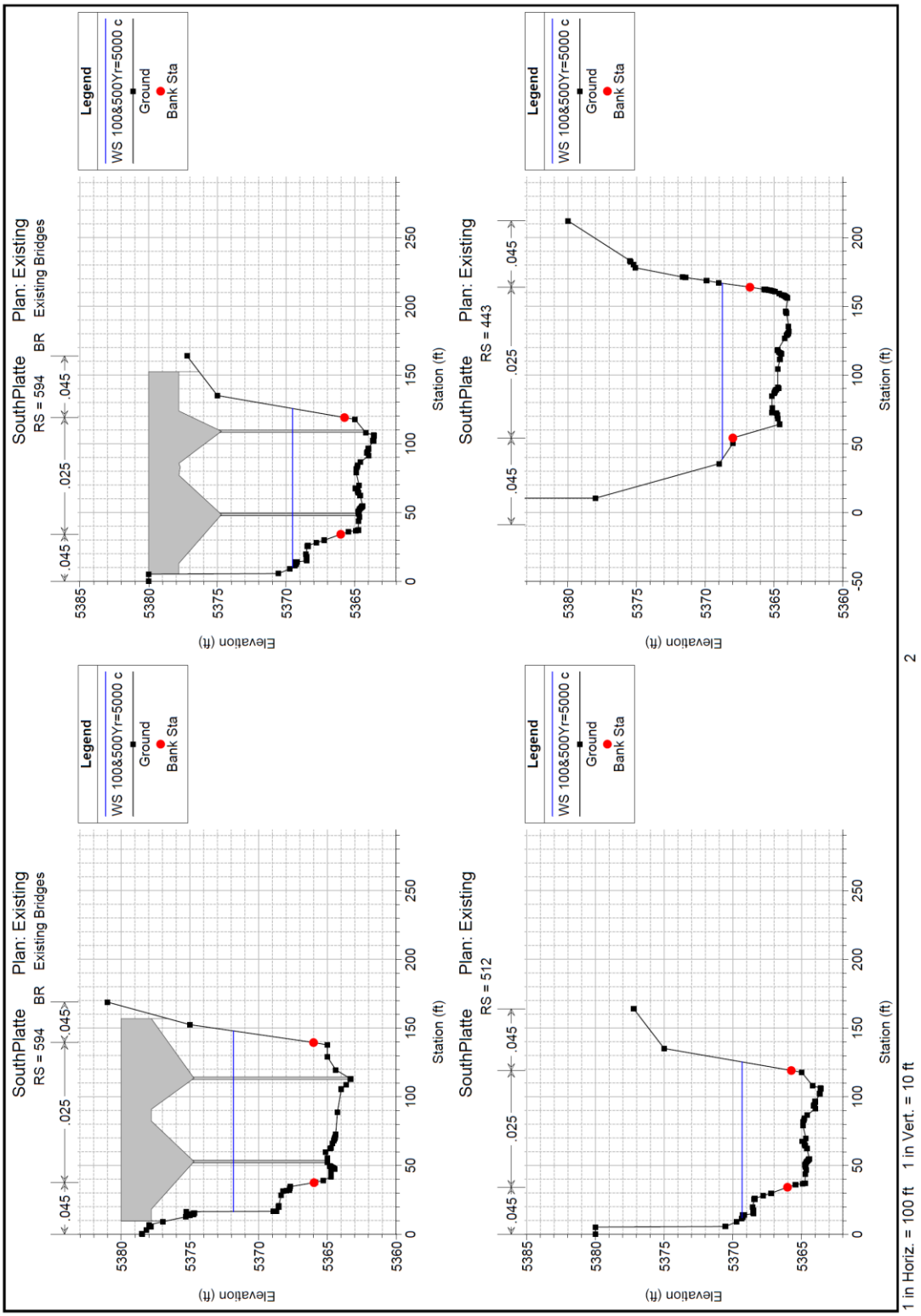
S. Platte River Bridge
Hydraulic Profiles
No Action & Proposed Action Alternatives


Legend
WS 100 & 500-Yr=50 - Proposed
WS 100 & 500-Yr=50 - Existing
Ground
Ground
Proposed Bridges
Existing Bridges
SouthPlatte Plan: 1) Proposed 2) Existing
South Platte Riv Bridge
Elevation (ft)
5380
5375
5370
5365
5360
0
200
400
600
800
1000
1200
1127
827
733
600
443
327
264
Main Channel Distance (ft)
1 in Horiz. = 200 ft 1 in Vert. = 5 ft

S. Platte River Bridge
Hydraulic Cross Sections
No Action Alternative

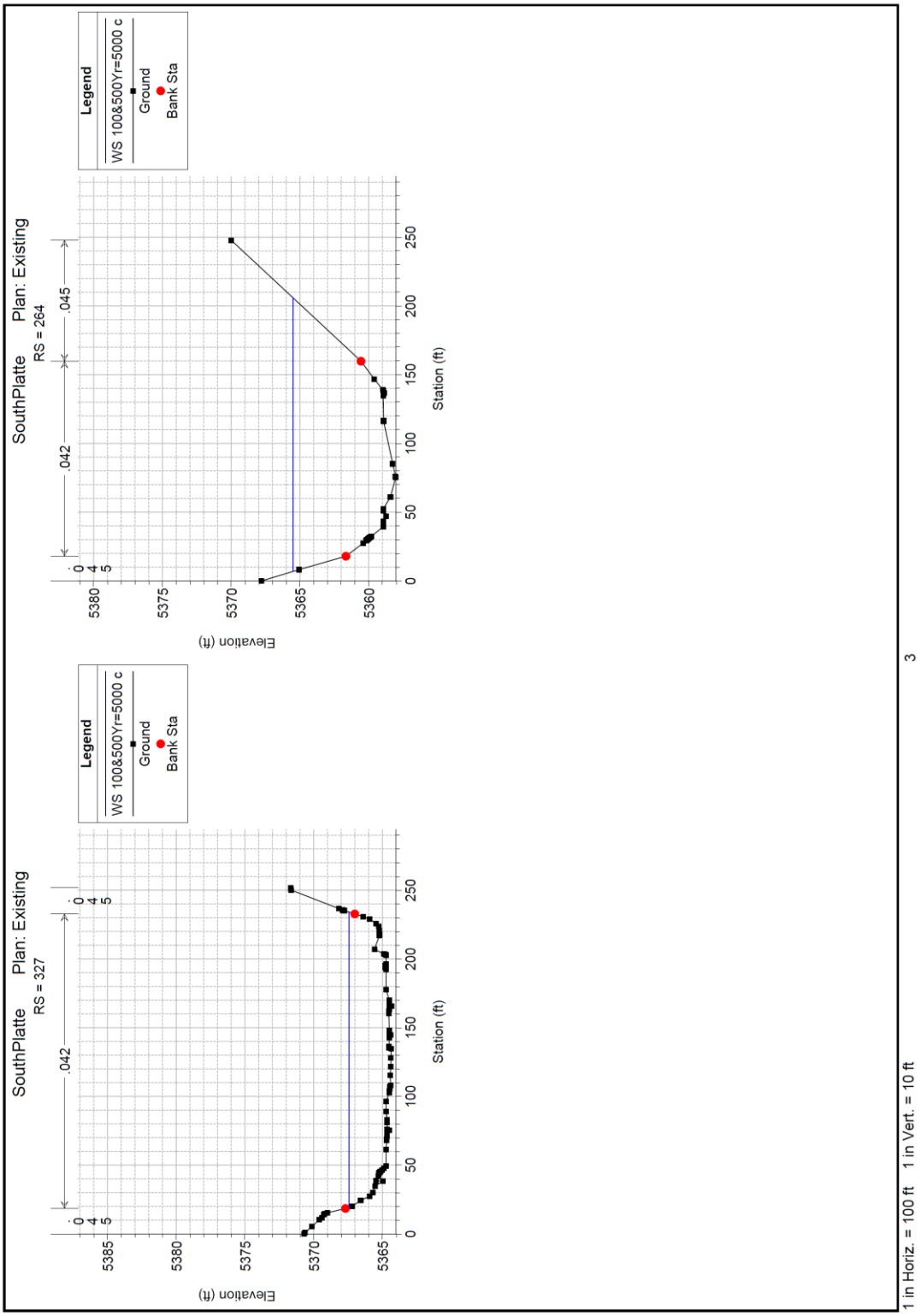

SouthPlatte Plan: Existing
RS = 827
SouthPlatte Plan: Existing
RS = 675
SouthPlatte Plan: Existing
RS = 1127
SouthPlatte Plan: Existing
RS = 733
Legend
WS 100&500Yr=5000 c
Ground
Bank Sta
Elevation (ft)
Station (ft)
1 in Horiz. = 100 ft 1 in Vert. = 10 ft

S. Platte River Bridge
Hydraulic Cross Sections
No Action Alternative



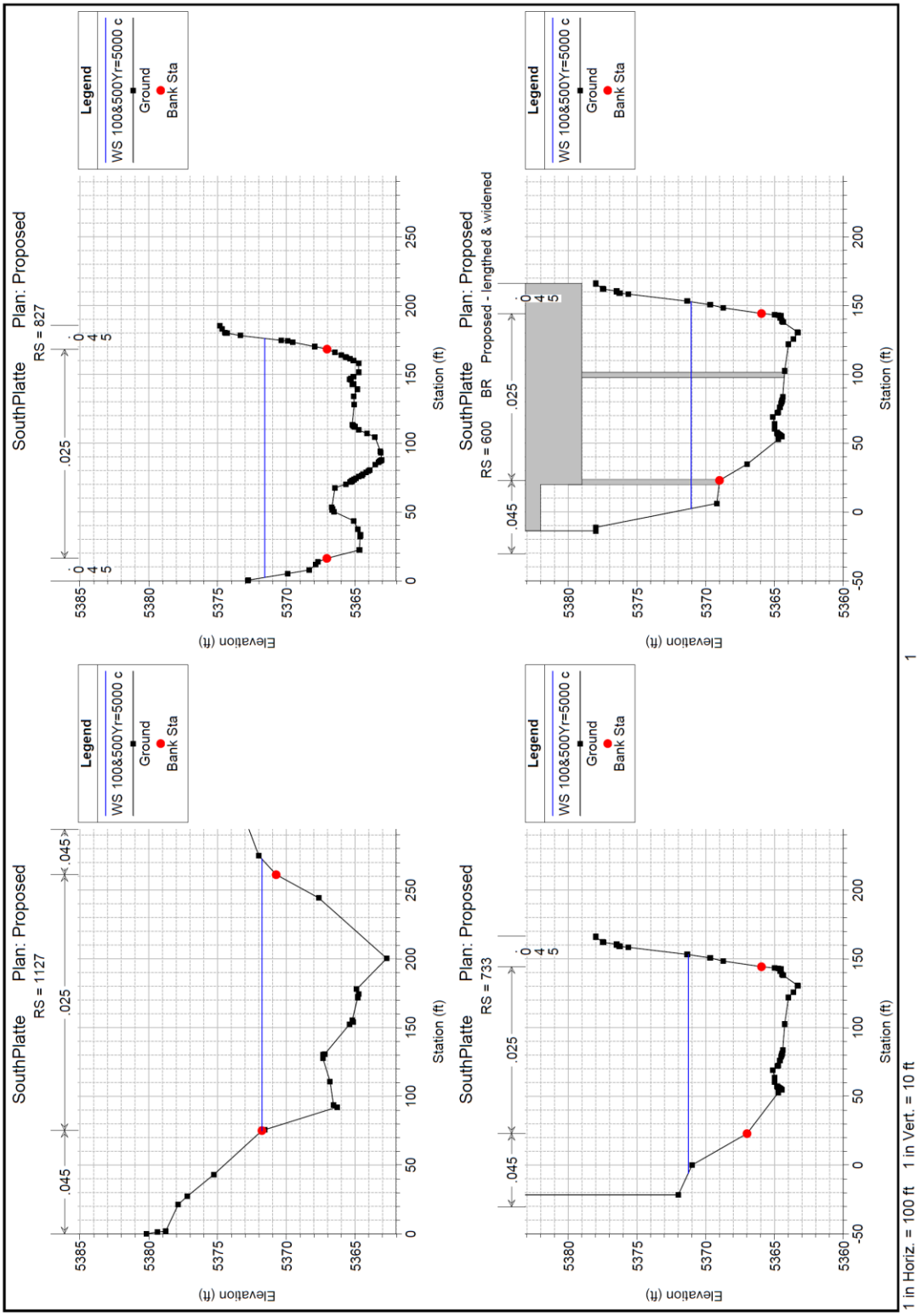
S. Platte River Bridge
Hydraulic Cross Sections

No Action Alternative



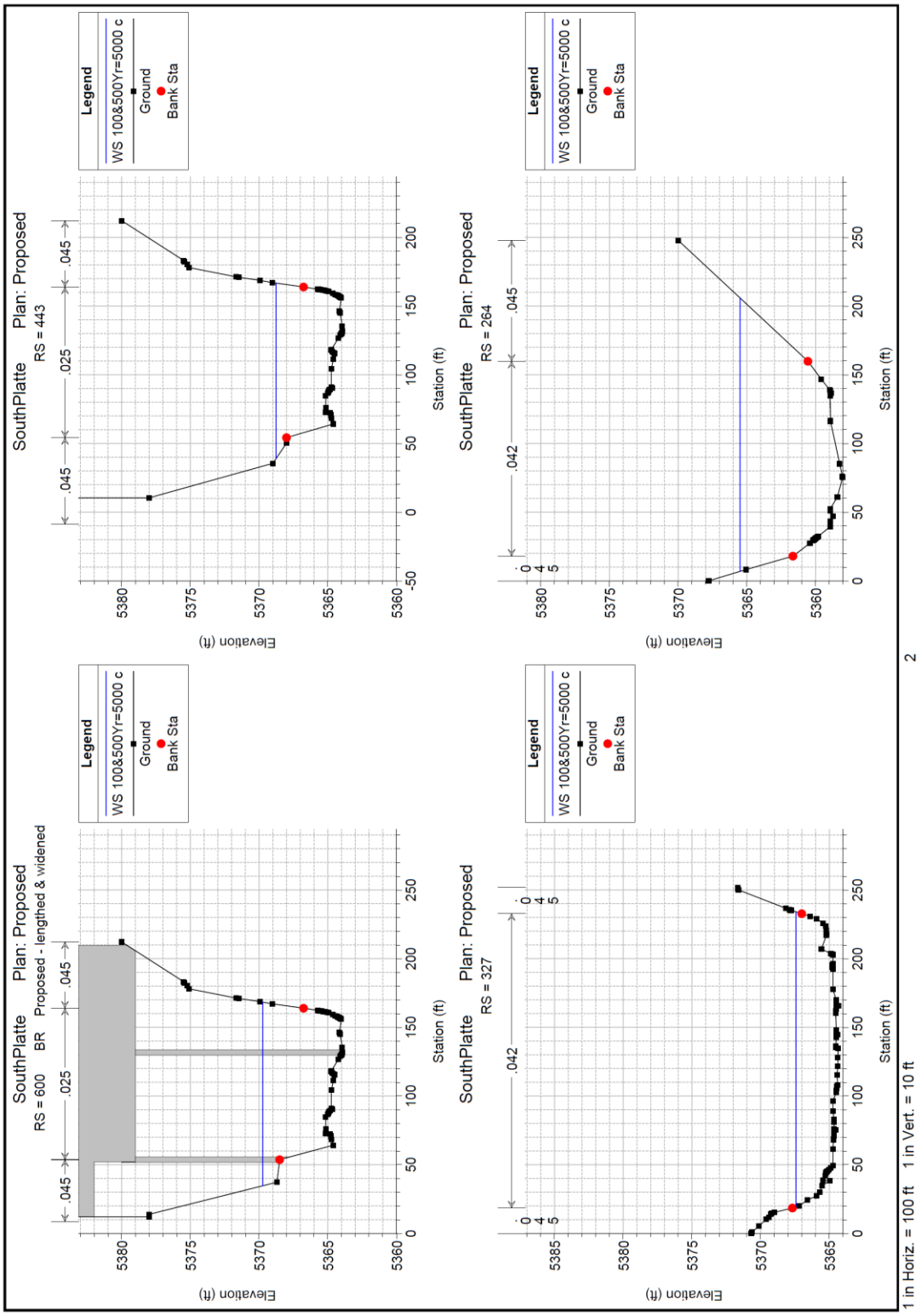
S. Platte River Bridge

Hydraulic Cross Sections
Proposed Action Alternative



S. Platte River Bridge
Hydraulic Cross Sections

Proposed Action Alternative



S. Platte River Bridge
Hydraulic Data
No Action & Proposed Action Alternatives

HEC-RAS River: South Platte Riv Reach: Bridge Profile: 100 & 500-Yr=50

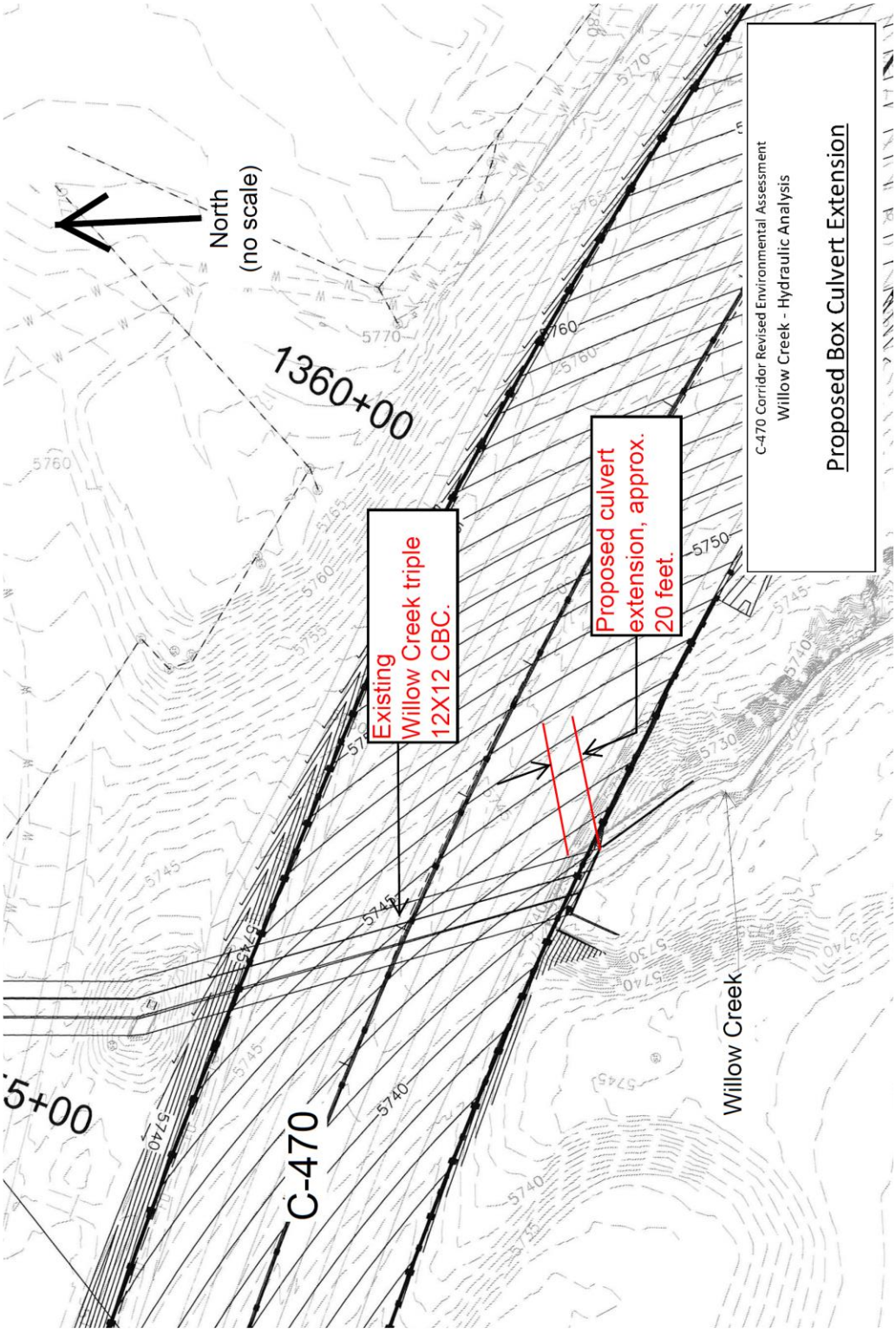
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Ch Sta L	Ch Sta R	Vel Chnl	Flow Area	Top Width
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(sq ft)	(ft)
Bridge	74	100 & 500-Yr=50	Existing	5000.00	5357.71	5364.36	15.37	114.77	8.45	727.76	262.09
Bridge	74	100 & 500-Yr=50	Proposed	5000.00	5357.71	5364.36	15.37	114.77	8.45	727.76	262.09
Bridge	264	100 & 500-Yr=50	Existing	5000.00	5358.04	5365.51	17.97	159.85	5.08	1054.39	199.19
Bridge	264	100 & 500-Yr=50	Proposed	5000.00	5358.04	5365.51	17.97	159.85	5.08	1054.39	199.19
Bridge	327	100 & 500-Yr=50	Existing	5000.00	5364.33	5367.45	18.51	232.72	9.11	549.17	214.94
Bridge	327	100 & 500-Yr=50	Proposed	5000.00	5364.33	5367.45	18.51	232.72	9.11	549.17	214.94
Bridge	443	100 & 500-Yr=50	Existing	5000.00	5363.93	5368.77	54.24	163.90	11.27	452.24	127.77
Bridge	443	100 & 500-Yr=50	Proposed	5000.00	5363.93	5368.77	54.24	163.90	11.27	452.24	127.77
Bridge	512	100 & 500-Yr=50	Existing	5000.00	5363.59	5369.33	34.19	119.08	12.06	444.03	113.24
Bridge	594 BR D	100 & 500-Yr=50	Existing	5000.00	5363.59	5369.54	34.19	119.08	12.05	447.11	111.27
Bridge	594 BR U	100 & 500-Yr=50	Existing	5000.00	5363.32	5371.83	37.53	139.43	6.63	819.51	127.41
Bridge	600 BR D	100 & 500-Yr=50	Proposed	5000.00	5363.95	5369.73	53.69	163.90	9.51	544.57	125.70
Bridge	600 BR U	100 & 500-Yr=50	Proposed	5000.00	5363.29	5371.07	22.93	144.25	6.86	766.80	142.32
Bridge	675	100 & 500-Yr=50	Existing	5000.00	5363.29	5371.93	37.53	139.43	6.33	862.13	131.55
Bridge	733	100 & 500-Yr=50	Existing	5000.00	5363.29	5372.18	22.93	144.25	5.36	1022.94	175.92
Bridge	733	100 & 500-Yr=50	Proposed	5000.00	5363.29	5371.29	22.93	144.25	6.14	871.36	159.20
Bridge	827	100 & 500-Yr=50	Existing	5000.00	5363.07	5372.38	16.13	168.30	4.36	1202.70	176.09
Bridge	827	100 & 500-Yr=50	Proposed	5000.00	5363.07	5371.58	16.13	168.30	4.91	1061.49	173.81
Bridge	1127	100 & 500-Yr=50	Existing	5000.00	5362.70	5372.52	75.08	261.15	4.24	1199.70	220.48
Bridge	1127	100 & 500-Yr=50	Proposed	5000.00	5362.70	5371.77	75.08	261.15	4.81	1044.24	197.40

Appendix B2

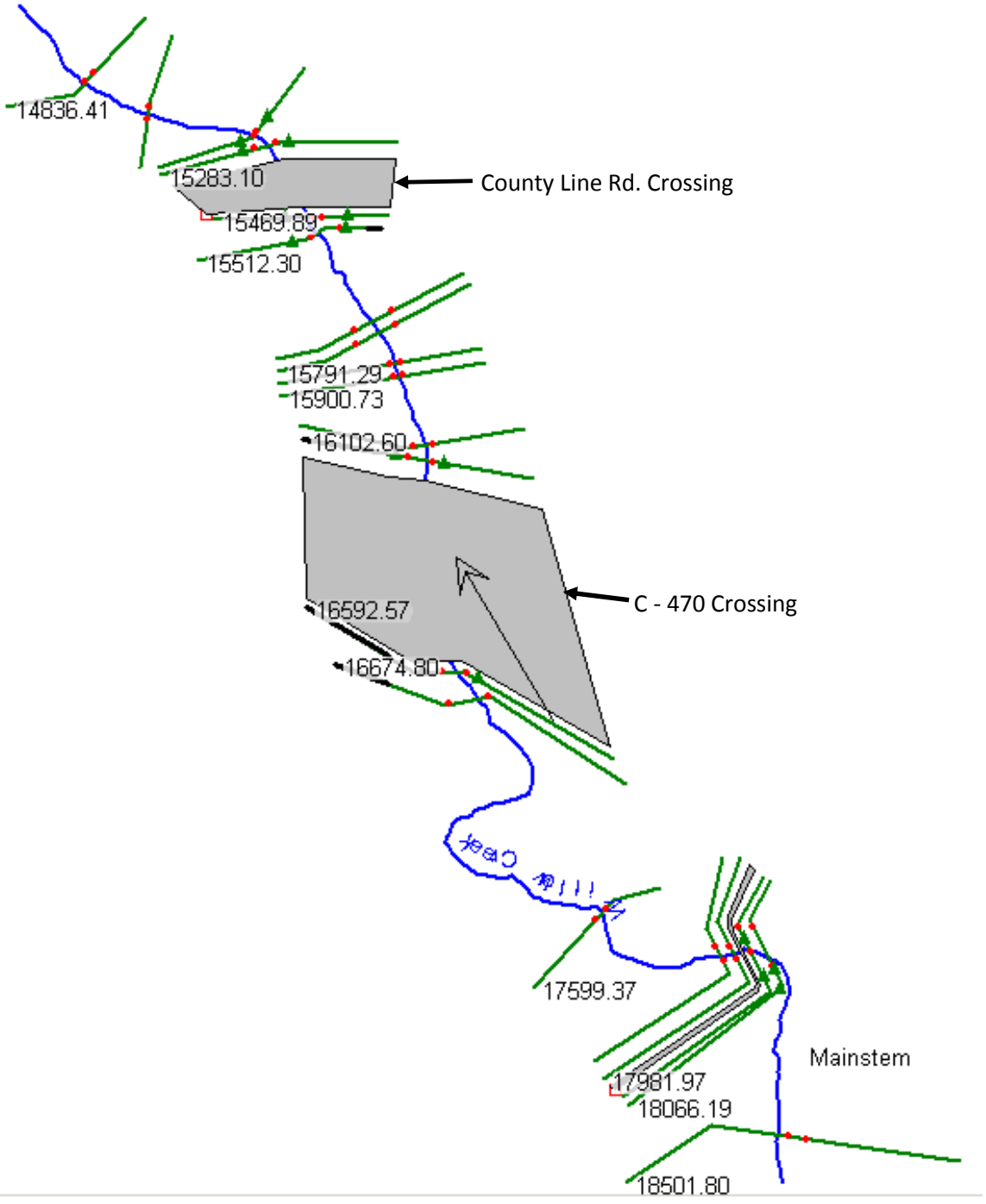
Willow Creek Culvert Extension

Hydraulic Analysis Data

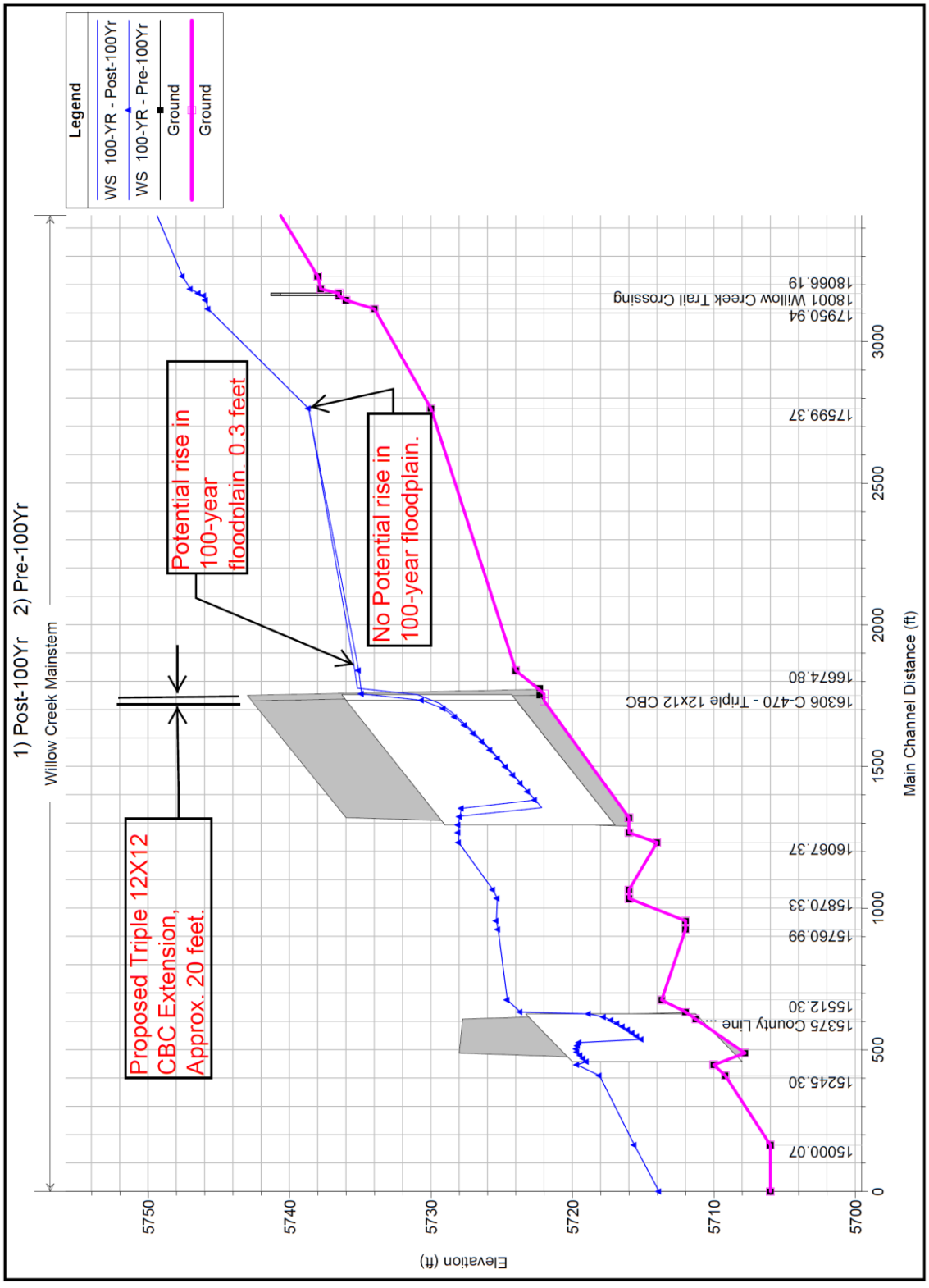
Willow Creek Culvert Extension
Plan View of Culvert Location
No Action & Proposed Action Alternatives


North
(no scale)
1360+00
5+00
C-470
Willow Creek
Existing
Willow Creek triple
12X12 CBC.
Proposed culvert
extension, approx.
20 feet.
C-470 Corridor Revised Environmental Assessment
Willow Creek - Hydraulic Analysis
Proposed Box Culvert Extension

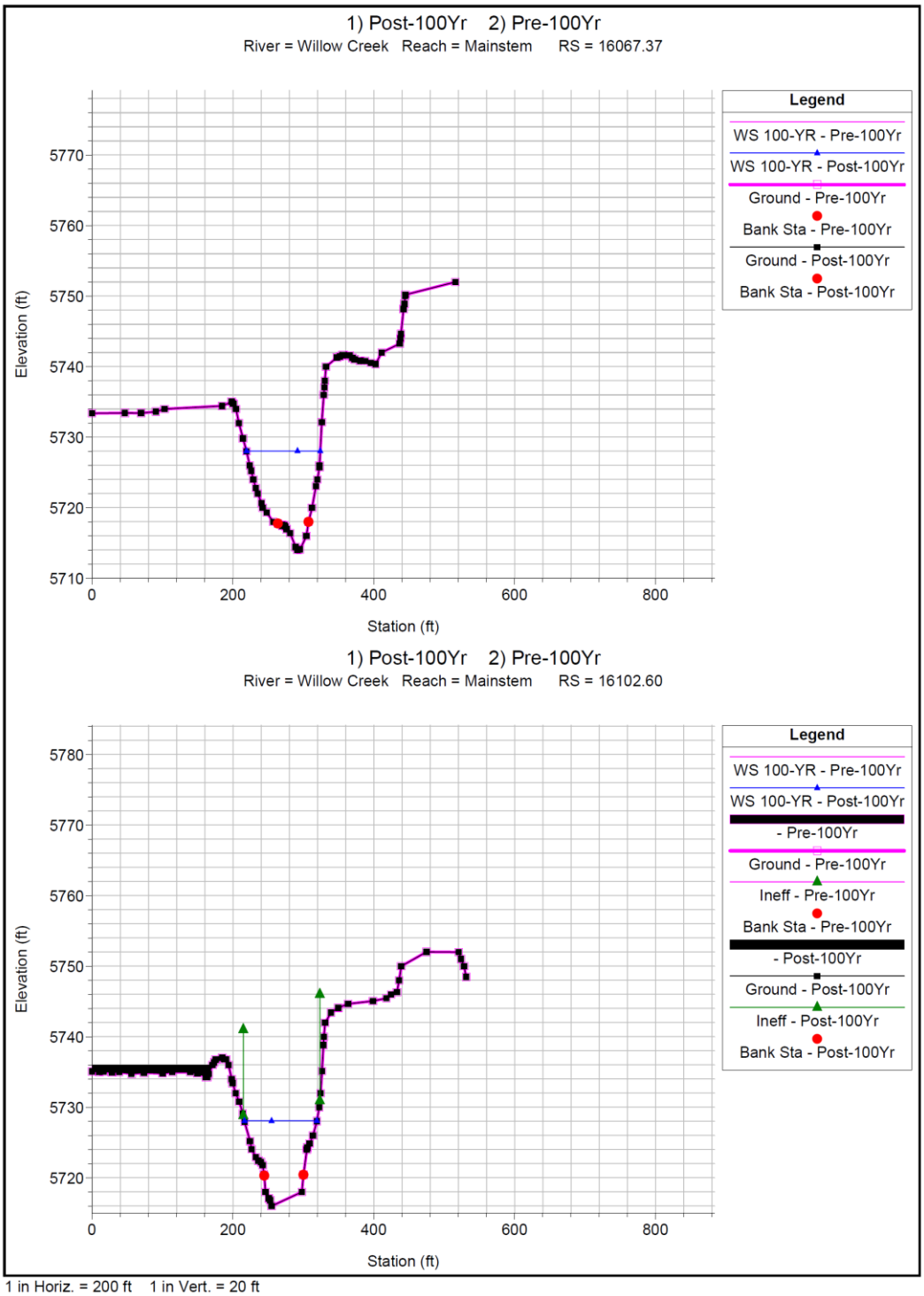
Willow Creek Culvert Extension
Hydraulic Plan Cross-Section Locations
No Action & Proposed Action Alternatives



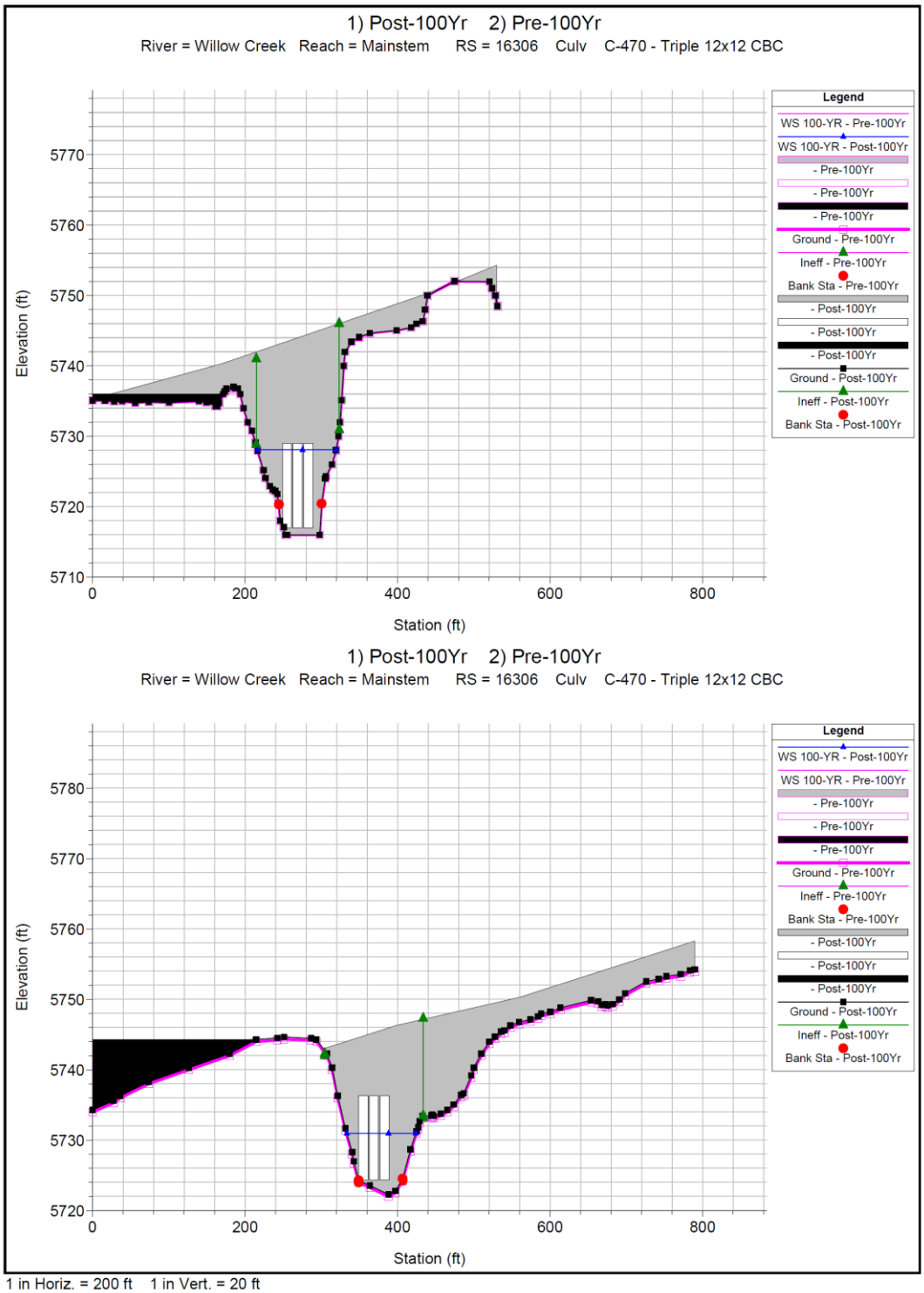
Willow Creek Culvert Extension
Hydraulic Profiles
No Action & Proposed Action Alternatives


Legend
WS 100-YR - Post-100Yr
WS 100-YR - Pre-100Yr
Ground
Ground
1) Post-100Yr 2) Pre-100Yr
Willow Creek Mainstem
Potential rise in 100-year floodplain. 0.3 feet
No Potential rise in 100-year floodplain.
Proposed Triple 12X12 CBC Extension, Approx. 20 feet.
16306 C-470 - Triple 12x12 CBC
15000.07
15245.30
15375 County Line
15512.30
15760.99
15870.33
16067.37
16674.80
17599.37
17950.94
18001 Willow Creek Trail Crossing
18066.19
Elevation (ft)
5700
5710
5720
5730
5740
5750
Main Channel Distance (ft)
0
500
1000
1500
2000
2500
3000
1 in Horiz. = 500 ft 1 in Vert. = 10 ft

Willow Creek Culvert Extension
Selected Hydraulic Cross Sections
No Action and Proposed Action Alternatives

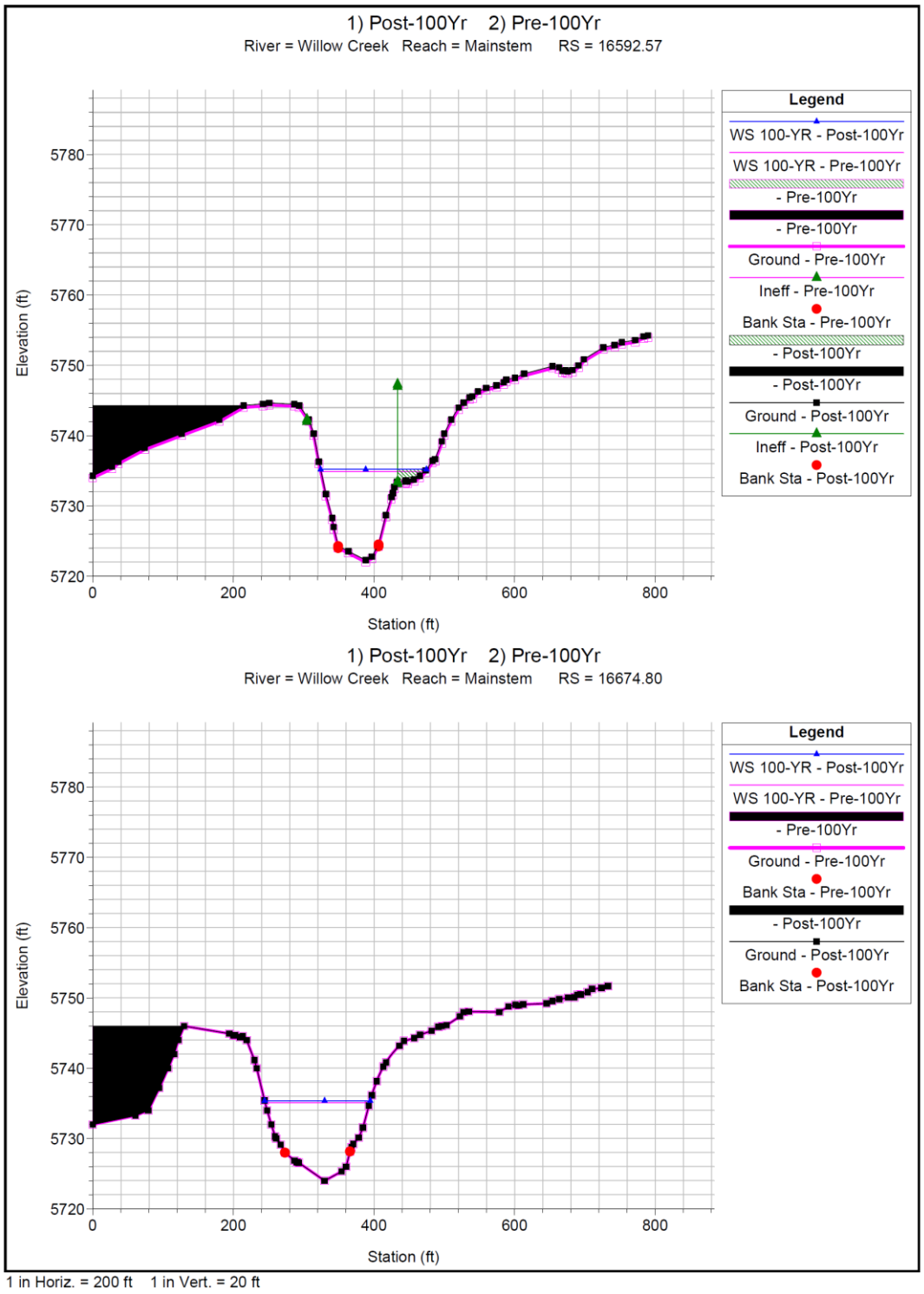


Willow Creek Culvert Extension
Selected Hydraulic Cross Sections
No Action and Proposed Action Alternatives

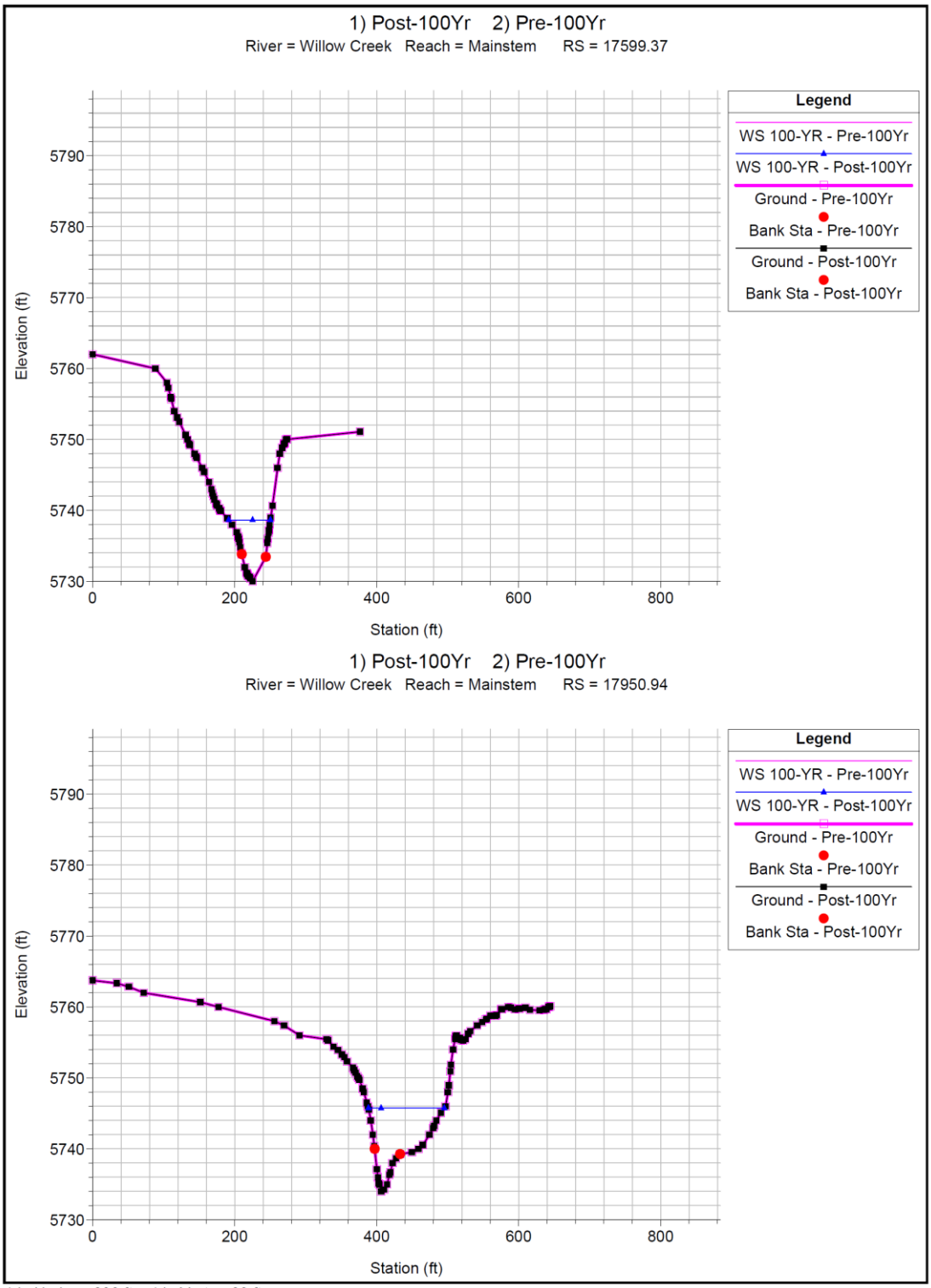


1 in Horiz. = 200 ft 1 in Vert. = 20 ft

Willow Creek Culvert Extension
Selected Hydraulic Cross Sections
No Action and Proposed Action Alternative



Willow Creek Culvert Extension
Selected Hydraulic Cross Sections
No Action Alternative



1 in Horiz. = 200 ft 1 in Vert. = 20 ft

Willow Creek Culvert Extension
Hydraulic Data
No Action & Proposed Action Alternative

HEC-RAS River: Willow Creek Reach: Mainstem Profile: 100-YR

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Ch Sta L	Ch Sta R	Vel Chnl	Flow Area	Top Width
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(sq ft)	(ft)
Mainstem	14836.41	100-YR	Post-100Yr	4236.00	5706.00	5713.87	179.46	208.48	8.88	688.68	156.56
Mainstem	14836.41	100-YR	Pre-100Yr	4236.00	5706.00	5713.87	179.46	208.48	8.88	688.68	156.56
Mainstem	15000.07	100-YR	Post-100Yr	4236.00	5706.00	5715.61	107.52	132.11	8.49	755.16	153.07
Mainstem	15000.07	100-YR	Pre-100Yr	4236.00	5706.00	5715.61	107.52	132.11	8.49	755.16	153.07
Mainstem	15245.30	100-YR	Post-100Yr	4236.00	5709.19	5718.08	230.93	242.35	12.48	446.63	100.95
Mainstem	15245.30	100-YR	Pre-100Yr	4236.00	5709.19	5718.08	230.93	242.35	12.48	446.63	100.95
Mainstem	15283.10	100-YR	Post-100Yr	4236.00	5710.00	5719.68	221.07	270.33	6.84	699.69	128.17
Mainstem	15283.10	100-YR	Pre-100Yr	4236.00	5710.00	5719.68	221.07	270.33	6.84	699.69	128.17
Mainstem	15375	100-YR	Post-100Yr	4236.00							
Mainstem	15375	100-YR	Pre-100Yr	4236.00							
Mainstem	15469.89	100-YR	Post-100Yr	4236.00	5712.00	5723.68	198.87	218.09	9.22	680.02	166.01
Mainstem	15469.89	100-YR	Pre-100Yr	4236.00	5712.00	5723.68	198.87	218.09	9.22	680.02	166.01
Mainstem	15512.30	100-YR	Post-100Yr	4236.00	5713.69	5724.60	249.50	316.00	4.37	1081.57	195.50
Mainstem	15512.30	100-YR	Pre-100Yr	4236.00	5713.69	5724.60	249.50	316.00	4.37	1081.57	195.50
Mainstem	15760.99	100-YR	Post-100Yr	3500.00	5712.00	5725.25	187.88	283.05	4.80	730.17	97.83
Mainstem	15760.99	100-YR	Pre-100Yr	3500.00	5712.00	5725.25	187.88	283.05	4.80	730.17	97.83
Mainstem	15791.29	100-YR	Post-100Yr	3500.00	5712.00	5725.37	188.93	289.14	4.87	718.84	91.17
Mainstem	15791.29	100-YR	Pre-100Yr	3500.00	5712.00	5725.37	188.93	289.14	4.87	718.84	91.17
Mainstem	15870.33	100-YR	Post-100Yr	3500.00	5716.00	5725.31	255.62	282.52	10.45	425.60	77.94
Mainstem	15870.33	100-YR	Pre-100Yr	3500.00	5716.00	5725.31	255.62	282.52	10.45	425.60	77.94
Mainstem	15900.73	100-YR	Post-100Yr	3500.00	5716.00	5725.62	262.65	283.44	12.15	374.68	67.81
Mainstem	15900.73	100-YR	Pre-100Yr	3500.00	5716.00	5725.62	262.65	283.44	12.15	374.68	67.81
Mainstem	16067.37	100-YR	Post-100Yr	3500.00	5714.01	5728.03	263.81	307.33	4.56	926.09	104.75
Mainstem	16067.37	100-YR	Pre-100Yr	3500.00	5714.01	5728.03	263.81	307.33	4.56	926.09	104.75
Mainstem	16102.60	100-YR	Post-100Yr	3500.00	5716.00	5728.07	244.44	300.21	5.09	784.26	102.96
Mainstem	16102.60	100-YR	Pre-100Yr	3500.00	5716.00	5728.07	244.44	300.21	5.09	784.26	102.96
Mainstem	16306	100-YR	Post-100Yr	3500.00							
Mainstem	16306	100-YR	Pre-100Yr	3500.00							
Mainstem	16592.57	100-YR	Post-100Yr	3500.00	5722.30	5735.20	349.03	406.53	4.16	977.32	150.51
Mainstem	16592.57	100-YR	Pre-100Yr	3500.00	5722.00	5734.90	349.03	406.53	4.16	977.29	150.51
Mainstem	16674.80	100-YR	Post-100Yr	3500.00	5724.00	5735.38	273.32	365.87	3.39	1148.56	150.37
Mainstem	16674.80	100-YR	Pre-100Yr	3500.00	5724.00	5735.11	273.32	365.87	3.51	1107.00	148.83
Mainstem	17599.37	100-YR	Post-100Yr	3500.00	5730.00	5738.65	210.03	243.86	13.62	287.04	58.73
Mainstem	17599.37	100-YR	Pre-100Yr	3500.00	5730.00	5738.65	210.03	243.86	13.62	287.04	58.73
Mainstem	17950.94	100-YR	Post-100Yr	3500.00	5734.00	5745.74	397.10	433.04	7.04	622.14	106.89
Mainstem	17950.94	100-YR	Pre-100Yr	3500.00	5734.00	5745.74	397.10	433.04	7.04	622.14	106.89
Mainstem	17981.97	100-YR	Post-100Yr	3500.00	5736.00	5745.92	457.45	490.50	8.18	550.71	106.93
Mainstem	17981.97	100-YR	Pre-100Yr	3500.00	5736.00	5745.92	457.45	490.50	8.18	550.71	106.93
Mainstem	18001 BR D	100-YR	Post-100Yr	3500.00	5736.51	5746.05	454.17	490.50	9.08	467.60	107.71
Mainstem	18001 BR D	100-YR	Pre-100Yr	3500.00	5736.51	5746.05	454.17	490.50	9.08	467.60	107.71
Mainstem	18001 BR U	100-YR	Post-100Yr	3500.00	5736.51	5746.43	489.28	557.04	7.68	524.94	123.14
Mainstem	18001 BR U	100-YR	Pre-100Yr	3500.00	5736.51	5746.43	489.28	557.04	7.68	524.94	123.14
Mainstem	18021.40	100-YR	Post-100Yr	3500.00	5737.78	5747.00	496.29	557.04	6.01	688.70	158.22
Mainstem	18021.40	100-YR	Pre-100Yr	3500.00	5737.78	5747.00	496.29	557.04	6.01	688.70	158.22
Mainstem	18066.19	100-YR	Post-100Yr	3500.00	5738.00	5747.56	494.49	594.39	3.46	1201.38	221.18
Mainstem	18066.19	100-YR	Pre-100Yr	3500.00	5738.00	5747.56	494.49	594.39	3.46	1201.38	221.18
Mainstem	18501.80	100-YR	Post-100Yr	3500.00	5743.33	5751.20	371.34	405.35	13.55	291.02	59.20
Mainstem	18501.80	100-YR	Pre-100Yr	3500.00	5743.33	5751.20	371.34	405.35	13.55	291.02	59.20